TNRCC PSTD LPST *SITE CLOSURE REQUEST FORM*

FINAL

JUSTIFICATION FOR CLOSURE FOR THE BASE EXCHANGE SERVICE STATION (SITE ST019), RANDOLPH AFB, TEXAS

AETC Contract No. F41689-96-D-0710
Order No. 5015

Prepared for

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE, TEXAS

and

12 CES/CEV
RANDOLPH AIR FORCE BASE, TEXAS

May 1998

Prepared by

PARSONS ENGINEERING SCIENCE, INC.
1700 Broadway, Suite 900
Denver, Colorado 80209

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TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
PETROLEUM STORAGE TANK DIVISION

LPST SITE CLOSURE REQUEST FORM

This form is to be used to request closure for Leaking Petroleum Storage Tank (LPST) cases. The soil and groundwater cleanup goals must be met prior to submitting this form. These cleanup goals should be derived from either:

- the TWC *Guidance Manual for LPST Cleanups in Texas*, January 1990 **so long as these goals were achieved prior to November 8, 1995**, or
- the TNRCC *Risk-Based Corrective Action for Leaking Storage Tank Sites* document, January 1994 (RG-36).

Submission of this Site Closure Request constitutes certification by the Responsible Party, Corrective Action Specialist (CAS), and Corrective Action Project Manager (CAPM) that all necessary corrective actions have been completed and final closure of the subject site is appropriate at this time. By signing this Site Closure Request, the Responsible Party, CAS, and CAPM acknowledges that no further corrective actions, with the exception of activities subsequently approved by the TNRCC, will be eligible for reimbursement after the RP's signature date. Although costs for activities such as groundwater monitoring or remediation system operation and maintenance may have been approved for an annual period, these activities should cease upon submission of the Site Closure Request as these activities will not be considered eligible for reimbursement beyond the date of the Site Closure Request. Additionally, any costs relating to site assessment or other corrective action activities will not be eligible for reimbursement if the activities are conducted after the date of the Site Closure Request, unless specifically approved by the TNRCC. If, upon review by the TNRCC, the TNRCC concurs that the site meets the conditions for final closure, the costs for closure activities necessary to restore the site to its original condition will be reviewed and approved as appropriate. If the TNRCC determines that the site does not meet the conditions for final closure, the TNRCC will request a workplan and cost proposal for the next appropriate corrective action activity necessary to proceed towards final closure unless appropriate activities have previously been approved. The only type of proposal that should be attached to the Site Closure Request is for site closure costs. Any proposals attached to the Site Closure Request for activities other than site closure will not be processed and will be withdrawn from consideration.

If any of the following apply, the site is not ready for closure and this form should not be submitted:

- **The appropriate LPST cleanup goals have not been met (a proposal for the next appropriate step should be submitted instead);**
- **Phase-separated hydrocarbons (>0.1 feet) currently exist at the site;**
- **The contaminant plume is increasing in size; or**
- **All wastes and other material generated from the site have not been properly disposed;**

Do not use this form:

- **if the release was not from a regulated underground or aboveground storage tank;**
- **for tank removal-from-service activities not associated with an LPST site (use the *Release Determination Report Form* (TNRCC-0621) or other appropriate format);**
- **for situations where the second set of confirmation samples collected during tank removal-from-service activities confirms suitability for closure (use the *Release Determination Report Form* (TNRCC-0621) or other appropriate format); or**
- **for shutdown of remediation systems or for plugging of monitor wells when site closure is not yet appropriate.**

If asked to initiate additional activities, submit a workplan and preapproval request for those activities on sites eligible for reimbursement. Please review the document entitled *Preapproval for Corrective Action Activities* (RG-111) for procedures on preapproval requests and the other PST guidance pamphlets and rules for additional information on LPST sites.

Complete all blanks and check "yes" or "no" for all inquiries. **IF A COMPLETED *ASSESSMENT REPORT FORM* (TNRCC-0562) WAS PREVIOUSLY SUBMITTED, YOU DO NOT NEED TO ANSWER THE QUESTIONS WITHIN THE DARK OUTLINED AREAS UNLESS THE INFORMATION HAS CHANGED.** If the question is not applicable to this site, indicate with N/A. If the answer to the question is unknown, please indicate. If space for supplemental information is needed, insert numbered footnote and provide brief supporting discussion in Section VI, Justification for Closure.

SITE CLOSURE REQUEST FORM

I. GENERAL INFORMATION

LPST ID No.: 91461 Facility ID No.:

Responsible Party: Department of the Air Force

Responsible Party Address: 1651 5th Street West City: San Antonio State: TX Zip: 78150

Facility Name: BX Service Station (Site ST-19), Randolph AFB, TX

Facility Street Address: 305 Tinker Drive

Facility City: San Antonio, Texas County: Bexar

What is the current use of site? (indicate all that apply):
☐ Residence[1] ☐ School or Day Care center ☒ Commercial/Industrial[1] ☐ Recreational ☐ Agricultural

What is the anticipated future use of the site? (indicate all that apply):
☐ Residence[1] ☐ School or Day Care center ☒ Commercial/Industrial[1] ☐ Recreational ☐ Agricultural

Adjacent property use (indicate all that apply):
☒ Residence[1] ☐ School or Day Care Center ☒ Commercial/Industrial[1] ☐ Recreational ☐ Agricultural

Distance to nearest off-site residence from property line: 50 feet in northeast direction.

Distance to nearest school or day care center from property line: _____ feet in _____ direction.

II. CLOSURE SCREENING INFORMATION

Based on the *Limited Site Assessment Report* form or the Risk-Based *Assessment Report Form* (TNRCC-0562), the site is currently a **Priority** 4 [a/] site. If the site priority has changed, list the other priorities that previously pertained to this site:

☒ Yes ☐ No — Have non-aqueous phase liquids (NAPL) ever been present at this site (including tankpit observation wells)? If yes, is NAPL present now (thickness ≥0.1 feet)? [1] ☐ Yes [1] ☒ No Current thickness: 0 ft. If NAPL is currently present, stop here and do not submit this form for case closure. Initiate or continue activities necessary for the removal of all recoverable NAPL at the site.

☒ Yes ☐ No — Were all soils, recovered contaminated groundwater, and any phase-separated hydrocarbons properly disposed of, treated, recycled or reused in accordance with TNRCC requirements? If No, stop here and do not submit this form. Provide a proposal (if the site is eligible for reimbursement) to properly dispose or otherwise manage the wastes/materials or, if the site is not eligible for reimbursement, provide documentation of proper disposition of the wastes.

☒ Yes ☐ No — Do contaminant concentrations show a consistent decreasing or low static trend? If No, is the contaminant plume increasing in size? ☐ Yes ☐ No **See Section VI.** If Yes, stop here, do not submit this form, and initiate activities to control plume migration.

[a/] As defined by TNRCC LSTP Risk-Based Corrective Action for Leaking Storage Tank Sites (TNRCC RG-36, 1994) guidance manual.

[1] See definition in 30 TAC 334.202

III. RELEASE ABATEMENT/REMEDIATION

Date Release Discovered: First Release -Summer, 1987; Second Release - Summer, 1996 See Section VI

Substance(s) released: *(check all that apply)* ☒Gasoline ☐Alcohol-blended fuel (Type and percentage of alcohol:_____)
☐Diesel ☐Used Oil [1] Jet Fuel (type:_____) ☒Aviation Gasoline ☐Other: *(be specific)*_____

Source of Release *(specify all that apply)*:
☒Spills/overfills ☒Piping leaks ☐Dispenser leaks ☐Tank corrosion [1] Other:_____

☒Yes ☐No Has a receptor survey been conducted?
☒Yes ☐No Has a water well inventory been conducted?

☐Yes ☒No Have vapor impacts to buildings or utility lines ever been associated with this release? If Yes, specify the measures taken to abate the impact and indicate the latest date that an impact was noted:

The second release (see Section VI) was from a AVGAS pipeline which may be considered a utility line.

☐Yes ☒No Have subsurface utilities ever been affected with NAPL or vapors by this release? If Yes, indicate the latest date that an impact was noted:_____

If not already provided in *Release Determination Report Form* (TNRCC-0621), or if the information has changed since submittal of the *Release Determination Report*, indicate number of tanks currently and formerly located at this site (attach pages as necessary):

	Type (UST/AST)	Product Type	Size (approx. gal)	
Current:	UST	gasoline	10,000	
	UST	gasoline	10,000	
	UST	gasoline	10,000	
	UST	gasoline	10,000	
				Date Removed from Service
Former:	UST	gasoline	10,000	1996
	UST	gasoline	10,000	1996
	UST	waste oil	500	1996
	UST	gasoline	10,000	1996
	UST	gasoline	12,000	1996

☒Yes ☐No If the tanks were permanently removed from service, were native soil samples collected from beneath the tanks **and** the entire length of the piping? If No, explain why not:

☒Yes ☐No Was a new UST system installed? If Yes, indicate the date, number of tanks and their contents:
See Above

☐Yes ☒No Are there any open excavations at the site? If Yes, state size, location, purpose, and status for each of the excavations: _____

Type(s) of soil remediation and time periods the remediation method was operational *(indicate all that apply)*:
☒Excavation 7/96 to 9/96 *(dates)*, and
[1] Aboveground Bioremediation/Aeration _____ to _____ *(dates)*, or
[1] Thermal Treatment _____ to _____ *(dates)*, or
[1] Disposal 7/96 to 9/96 *(dates)*.
☐Soil Vapor Extraction _____ to _____ *(dates)*.
☒In-Situ Bioremediation 12/97 to Present *(dates)*.
☐None

III. RELEASE ABATEMENT/REMEDIATION (Continued)

Type(s) of groundwater remediation and time periods the remediation method was operational *(indicate all that apply)*: N/A

☐ Groundwater Pump and Treat _____ to _____ *(dates)*

☐ Air Sparging/SVE _____ to _____ *(dates)*

☐ In-Situ Bioremediation _____ to _____ *(dates)*

☐ Other: _____ _____ to _____ *(dates)*

☒ None

☒ Yes ☐ No Were copies of all receipts and manifests to document disposition of all wastes submitted to the TNRCC? If No, attach copies to this form.

Measured total volume of NAPL recovered: <1.0 gallons.

Estimated total volume of soil removed: 475 cubic yards *(exclude soil cuttings removed from borings)*.

Estimated total volume of groundwater treated/removed: 0 gallons *(if known)*.

Estimated pounds of hydrocarbons removed or treated from soil *(if known)*: Not available

Estimated pounds of hydrocarbons removed or treated from groundwater *(if known)*: Not available

Estimated percent of total contaminants removed or treated *(if known)*: Not available

IV. SOIL DATA VALIDATION

Are there now affected surface soils (contamination exceeding health-based target concentrations) present within 2 feet below the ground surface? ☐Yes ☒No ☐Unknown

Type of surface cover over affected surface soil area:

☒Paved [☒Asphalt or ☐Concrete] Percent of affected soils covered? 80 ☐Unpaved

☐Other:_____

Is there public access to the uncovered affected surface soil area? ☐Yes ☒No

Total number of borings: 18 (including those completed as monitor wells)

☒Yes ☐No Was the vertical and horizontal extent of soil impacts defined (to the more stringent of health-based target or groundwater protective soil concentrations horizontally and to groundwater or nondetect vertically) by the borings?

☐Yes ☒No Are shallow (0-15 feet below ground surface) soils affected (contaminant levels exceed health-based target concentrations) on adjacent properties (including right-of-way properties).

☒Yes ☐No Were all soil sample collection, handling, transport, and analytical procedures conducted in accordance with TNRCC and EPA requirements? If No, provide justification:_____

MAXIMUM SOIL CONCENTRATION LEVELS

Soil Contaminants	Sample Date	Sample Location	Depth (in feet below ground surface)	Analytical Method	Maximum Concentration* (mg/kg)	Target Cleanup Goals** (indicate source of target cleanup goals: 1990 or 1994 [Plan A or B] guidance)[a/]
Benzene	7/25/91	FM-4	~10	USEPA 8020	<2	0.74
Toluene	7/25/91	FM-4	~10	USEPA 8020	31	503
Ethylbenzene	7/25/91	FM-4	~10	USEPA 8020	12	835
Total Xylenes	7/25/91	FM-4	~10	USEPA 8020	85	968
Total BTEX	7/25/91	FM-4	~10	USEPA 8020	128	--
TPH	7/25/91	FM-4	~10	USEPA 418.1	610	--
Other Total Lead	11/87	ST019SB264	8	USEPA 6010A	10	NA(400)[b/]
Other_____						

* **Enter maximum soil analytical results for soils remaining beneath the site (take into account all available data, including information obtained during the release determination (tank removal from service, minimal site assessment, etc)).**

** **If Plan A cleanup goals were used, provide the potential groundwater beneficial use category and a justification of how it was determined in Section VI.**

1990 cleanup goals may be used only if all activities necessary to meet those goals were completed by November 8, 1995.

a/ **Category II Plan A Groundwater Protective (mg/kg), TNRCC, 1994.**

b/ **NA (400) = TNRCC criteria not available. A screening level of 400 mg/kg is presented based on Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities (USEPA, 1994)**

V. GROUNDWATER DATA VALIDATION

Is groundwater at the site impacted? ☒Yes ☐No

Did the assessment document that groundwater was not impacted? ☐Yes ☒No If No or unsure, provide justification for not determining whether there is a groundwater impact: Groundwater impact was demonstrated.

Total number of monitoring wells installed: 12

Will any of the remaining wells be used in the future? ☐Yes ☒No If Yes, specify exactly which well(s) will be used: ____

If No, they must be plugged in accordance with 30 TAC Chapter 338 **after** obtaining approval for site closure. **Do not** plug the wells until you receive concurrence on site closure. Costs of well plugging may be allowable for reimbursement if all eligibility requirements are met and if the wells were installed under the direction of the TNRCC specifically to address the confirmed release at the site. Provide a proposal with this form (if the site is eligible for reimbursement) for costs of the well plugging.

Measured total dissolved solids (TDS) concentration in groundwater: <3,000 mg/l. From which monitor well(s) was/were the sample(s) collected? Estimated based on specific conductivity readings at site monitor wells.

Measured groundwater yield at the site: 380 gallons/day (as determined from well adequately screened in the impacted aquifer). ☐Not determined.

Measured groundwater depth at the site ranges between 20 and 25 feet below the top of well casing.

Time period of groundwater monitoring at the site *(dates)*: 11/90 to 11/97.

Total number of groundwater monitoring events: 13.

What type of aquifer is impacted? (unconfined, confined, semi-confined): unconfined.

Distance from maximum plume concentration point to nearest existing downgradient well location (not monitor well): >0.5 mile _____ direction (Input ">0.5 mile" if there is no well within 0.5 mile downgradient)

Are any water supply wells impacted or immediately threatened? ☐Yes ☒No
If Yes, specify type of well: ☐Drinking water ☐Non-drinking water

Are there any existing water wells located within the area of impacted groundwater? ☐Yes ☒No
If Yes, specify type of well: ☐Drinking water ☐Non-drinking water

Has surface water been affected? ☐Yes ☒No

Will the groundwater contaminants likely discharge to a surface water body? ☐Yes ☒No

What is the potential impact of affected groundwater discharge on surface water?
☐Current impact ☐Discharges within 500 ft. ☐Discharges within 500 to 0.25 miles
☒No potential impact

☒Yes ☐No Were groundwater sample collection, handling, transport, and analytical procedures conducted and documented in accordance with TNRCC requirements? If no, provide justification: ____

V. GROUNDWATER DATA VALIDATION (Continued)

☒Yes ☐No Is the extent of groundwater contamination defined (to MCL concentrations)? If No, provide justification for not defining the plume:_____

☐Yes ☒No Have groundwater impacts from this release been detected on adjacent properties? If No, is off-site migration probable? ¹ Yes ¹ ☒ No Is there documentation that off-site migration has **not** occurred (sample results from off-site sampling point)? ¹ ☒ Yes ¹ No

☐Yes No Was the static groundwater level above the top of the well screen in any monitor wells during any of the last 4 monitoring events? If Yes, provide a statement of validity regarding these samples:

☐Yes ☒No Have groundwater samples from all monitor wells met the target cleanup goals for the last four consecutive sampling events?

MAXIMUM GROUNDWATER CONCENTRATIONS

Groundwater Contaminants	Sample Date	Sample Location	Laboratory Method	Maximum Concentration* (mg/l)	Target Cleanup Goals** *(indicate source of target cleanup goals: 1990 or 1994 [Plan A or B] guidance)* a/
Benzene	11/13/97	ST019MW072	USEPA 8020	7.1	0.0294
Toluene	11/16/97	ST019MW260	USEPA 8020	5.2	7.3
Ethylbenzene	11/16/97	ST019MW260	USEPA 8020	0.43	3.65
Total Xylenes	11/16/97	ST019MW260	USEPA 8020	3.1	73
Total BTEX	11/16/97	ST019MW260	USEPA 8020	12.03	--
TPH			--		--
Acenaphthene	11/16/97	ST019MW260	USEPA 8310	0.028	2.19
Anthracene	11/12/97	ST019MW077	USEPA 8310	0.000044	11
Fluoranthene	11/16/97	ST019MW260	USEPA 8310	0.0012	1.46
Fluorene	11/13/97	ST019MW072	USEPA 8310	0.0017	1.46
Naphthalene	11/13/97	ST019MW072	USEPA 8310	0.120	1.46
Phenanthrene	11/16/97	ST019MW260	USEPA 8310	0.002	NA b/
Pyrene	11/16/97	ST019MW260	USEPA 8310	0.001	1.1
Other Lead (total)	11/12/97	ST019MW074	USEPA 7421	0.021	NA
Other MTBE	11/16/97	ST019MW260	USEPA 8020	34	NA

* Enter maximum groundwater analytical results from the most recent 12 months of monitoring.

** 1990 cleanup goals may be used only if all activities necessary to meet those goals were completed by November 8, 1995.

a/ Category II Plan A Groundwater Concentration (mg/L) (TNRCC, 1994).

b/ NA = Groundwater criteria not available from TNRCC.

VI. JUSTIFICATION FOR CLOSURE

Please provide a brief summary supporting this request for site closure, including footnoted discussions for the above entries as necessary. **Include discussions providing necessary justifications for any site conditions which deviate from the specific requirements of TNRCC rules and policies, including the document *Risk-Based Corrective Action for Leaking Storage Tank Sites*.** Provide documentation to justify case closure, including information which addresses the potential for future exposure, the existence of impervious cover or other actions which may prevent exposure or limit infiltration, the absence of receptors, etc.

See Attachment 1

VII. REPORT PREPARATION

Based on the results of the site investigation and the additional information presented herein, I certify that the site investigation activities performed either by me, or under my direct supervision, including subcontracted work, were conducted in accordance with accepted industry standards/practices and further, that all such tasks were conducted in compliance with applicable TNRCC published rules, guidelines and the laws of the State of Texas. I have reviewed the information included within this report, and consider it to be complete, accurate and representative of the conditions discovered during the site investigation. I acknowledge that if I intentionally or knowingly make false statements, representations, or certifications in this report, I may be subject to administrative, civil, and/or criminal penalties. **I certify that the site has met all requirements for closure and that closure is appropriate.**

Project Manager: Brian Vanderglass CAPM No.: 00758 Expiration date: 8/10/98

Company: Parsons Engineering Science, Inc.

Address: 800 Centre Park Dr., Suite 200 City: Austin State: TX Zip: 78754

Telephone No.: (512) 719-6000 Fax No.: (512) 719-6099

Signature: Brian Vanderglass Date: May 13, 1998

By my signature affixed below, I certify that I am the duly authorized representative of the Correction Action Specialist named and that I have personally reviewed the site investigation results and other relevant information presented herein and considered them to be in accordance with accepted standards/practices and in compliance with the applicable TNRCC published rules, guidelines and the laws of the State of Texas. Further, that the information presented herein is considered complete, accurate and representative of the conditions discovered during the site investigation. I acknowledge that if I intentionally or knowingly make false statements, representations, or certifications in this report, I may be subject to administrative, civil, and/or criminal penalties. **I certify that the site has met all requirements for closure and that closure is appropriate.**

Corrective Action Specialist: Brian Vanderglass CAS No.: 00101 Expiration date: 10/16/98

Company: Parsons Engineering Science, Inc.

Address: 800 Centre Park Dr., Suite 200 City: Austin State: TX Zip: 78754

Telephone No: (512) 719-6000 Fax No.: (512) 719-6099.:

Signature: Brian Vanderglass Date: May 13, 1998

By my signature affixed below, I certify that I have reviewed this report for accuracy and completeness of information regarding points of contact and the facility and storage tank system history and status. I acknowledge that if I intentionally or knowingly make false statements, representations, or certifications in this report related to the contact information, and the facility and storage tank system history and status information, I may be subject to administrative, civil, and/or criminal penalties. I attest that I have reviewed this report for accuracy and completeness. I understand that I am responsible for addressing this matter.
I certify that the site has met all requirements for closure and that closure is appropriate.

Name of Responsible Party contact: _____

Telephone No.: _____ Fax No.: _____

Signature: _____ Date: _____

THE FOLLOWING ITEMS MUST BE SUBMITTED WITH THIS FORM IF NOT PREVIOUSLY SUBMITTED:

- A site map illustrating the locations of the entire UST and/or AST system (including piping, dispensers, observation wells, etc.), all soil borings and monitoring wells and all other sampling points, subsurface utilities, and surface water within 500 feet.
- A copy of the latest groundwater gradient map (if monitor wells were completed).
- Summary tables of all soil, groundwater and surface water analytical results, including samples collected from any tank removal from service activities, tank system repair activities, and those collected from borings and monitor wells. The tables must clearly identify the sample number, date of collection, sampling locations, depths (if applicable), and analytical results.
- Copies of any manifests or other waste receipts, and any other documents necessary for case closure.

TNRCC PSTD LPST *SITE CLOSURE REQUEST FORM*
SECTION VI

FINAL

JUSTIFICATION FOR CLOSURE FOR THE BASE EXCHANGE SERVICE STATION (SITE ST019), RANDOLPH AFB, TEXAS

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Prepared by

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1700 Broadway, Suite 900
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LIST OF EXHIBITS

SECTION VI

Justification for closure based on the Texas Natural Resource Conservation Commission (TNRCC) Interoffice Memorandum *Process for Closure Evaluation of Petroleum Hydrocarbon LPST Sites Exceeding Target Concentrations* (TNRCC, 1997a) is provide herein. This documentation fulfills the requirements of Section VI of the TNRCC Petroleum Storage Tank Division (PSTD) LPST *Site Closure Request Form* (TNRCC-0028). The work is being performed by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence, Technology Transfer Division (AFCEE/ERT), under Air Education and Training Command (AETC) Contract No. F41689-96-D-0710, Order No. 5015.

RELEASES

The original release at the BX Service Station was thought to have occurred via the UST appurtenances (i.e., valves, piping) which were replaced in early 1989 (see Exhibit A) (designated as the "UST release"). An inventory record examination revealed that between 200 and 2,000 gallons of fuel had potentially been released prior to the summer of 1987. In 1989, all of the USTs passed tank tightness testing. Information regarding this release and the subsequent investigations have been documented in numerous reports. In the summer of 1996, an abandoned aviation gasoline (AVGAS) line was severed during Base construction activities, resulting in the release of an unknown quantity of fuel to the subsurface (see Exhibit A) (designated as the "AVGAS release").

Subsequent to the AVGAS release, free product was found in well ST019MW074 to the northwest of the release point, presumably from the ruptured AVGAS line. Versar Inc., San Antonio, Texas performed free-product recovery in December 1996 and January 1997 (Versar, 1997). Free product was recovered from ST019MW074. Less than a gallon of product was recovered during this effort. Subsequent sampling events in June 1997 (Weston, 1997) and November 1997 indicated no free product present in this or any other wells at the site.

Investigation activities have been completed to assess the consequences of the AVGAS release with respect to subsurface contamination and are reported herein. In addition, a bioventing pilot system has been installed at the AVGAS release location for source removal. The bioventing system was put into operation in December 1997 and is expected to continue operating for one year.

REGULATORY REQUIREMENTS

The BX Service Station site is currently regulated by the Petroleum Storage Tank (PST) Division of the TNRCC. The TNRCC designation for this site is LPST ID No. 93205. Published guidance entitled *Risk-Based Corrective Action for Leaking Underground Storage Tank (UST) Sites* (TNRCC, 1994) contains information regarding the risk-based corrective action process and the establishment of remediation targets for sites regulated by the PST Division. Additional guidance regarding case closure criteria at low-risk leaking UST sites became available in February 1997 (TNRCC, 1997). In summary, the guidance indicates that site closure is appropriate if the following criteria are met:

1. The groundwater contaminant plume is stable or declining in magnitude and/or size. Plume stability can be demonstrated by at least four groundwater monitoring events. In addition, natural attenuation indicators can be used to demonstrate trends suggesting natural attenuation is occurring and is likely to continue to occur which would lead to declining contaminant concentrations. This is detailed in the TNRCC Interoffice Memorandum *Interim Guidance: Monitoring Natural Attenuation for Verification of Groundwater Plume Stability* (TNRCC, 1997b); and

2. Current or future exposure potential is low such as typical Priority 4.1 and 4.2 sites. This can be demonstrated by developing a conceptual site model which details the potential for current and future exposures. To aid in this closure process, the TNRCC has developed a series of decision flow charts which should be used by owner/operators to evaluate groundwater and exposure pathways. Institutional controls can be used to restrict exposure potential (e.g., no groundwater utilization) and still proceed to closure. These flow charts have been included as Figures 1 through 3. Each has been annotated with site-specific justification which leads the site to closure.

The above two criteria have been met, therefore closure of the site is being sought by completing a *Leaking Petroleum Storage Tank (LPST) Closure Request Form* (TNRCC, 1996).

ADDITIONAL SITE INFORMATION

Information regarding the site which has not been submitted previously to the TNRCC is included as Exhibits A though N. This work was performed as part of an AFCEE demonstration project evaluating risk-based investigation and closure of low-risk sites. The work was performed in accordance with the *Final Work Plan for the Risk-Based Investigation and Closure of the Base Exchange Service Station, Randolph Air Force Base, Texas* (Parsons ES, 1997). The data gathered during this demonstration is used to augment data previously collected at the BX Service Station to support closure. Data collection activities included:

- Installation and soil sampling of 5 soil borings in the vicinity of the recent AVGAS release;
- Soil sampling to support the natural attenuation evaluation of the dissolved groundwater plume (total organic carbon [TOC] measurements);
- Soil gas sampling near areas of concern; and
- The installation of additional groundwater monitoring wells (ST019MW258 [dry - abandoned], ST019MW259, ST019MW260) and collection of geochemical and contaminant data from these wells and selected preexisting site monitoring wells;
- Collection of site-specific hydraulic conductivity data (slug tests).

BACKGROUND GROUNDWATER LEAD CONCENTRATIONS

During the field investigation, selected groundwater samples were analyzed for total lead. Total lead concentrations in groundwater ranged from non-detectable levels to 0.021 milligrams per liter (mg/L). This is within the range of background groundwater concentrations (0.005 to 0.025 mg/L) reported in the Final Basewide Groundwater Assessment Report For Randolph AFB, Texas (Weston, 1997). This suggests that no lead contamination exists on-site attributable to the multiple releases. Thus, no further discussion of lead is provided within this narrative.

EXPOSURE POTENTIAL

Based on the Conceptual Site Model (CSM), air, soil, and shallow groundwater represent the potentially affected physical media at the BX Service Station. No surface water is present within approximately 1,200 feet of the site, and available data indicate that no contaminant migration pathway from the site to surface water, either through overland runoff or groundwater discharge, is completed. Therefore, surface water is not considered to be an affected medium.

Randolph AFB is an active military base. Surrounding land use is primarily agricultural and commercial. The site is currently an active service station which could be considered commercial in nature. Residential housing is present 50 feet northwest of the site. No change is seen in the foreseeable future for the activities and potential receptors at the site. The base boundary is located approximately 1,900 feet to the northwest of the site. Off-Base, changes in land use may include development of agricultural areas for residential or commercial purposes east and south of Randolph AFB (USACE, 1991).

Based on these land use assumptions, commercial worker populations and construction worker populations are the only current or foreseeable future on-site human receptors. Because there are no long-term plans for the use of groundwater from the shallow affected aquifer, and because depth to groundwater at the site is approximately 25 feet below ground surface (bgs), it is reasonable to assume that current on-site workers would be exposed only to impacted subsurface soils and to air potentially affected by chemicals volatilizing from subsurface media. However, maximum detected benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations remaining in soil are below TNRCC (1997) target concentrations for construction worker exposures. In addition, maximum detected lead concentrations in soil are below the screening level of 400 mg/kg reported in the *Revised Interim Soil Lead Guidance for CERCLA Site and RCRA Corrective Action Facilities* (USEPA, 1994) (no TNRCC criteria available). No PAHs were detected during the most recent soil sampling. To assess risks posed by possible vapor inhalation by construction workers, three soil gas samples were collected near ST019MW077, near the historic UST locations to the east of the building, and near ST019MW074 (Exhibit B). Collection of a soil gas sample was attempted near the AVGAS release point (ST019SV003), but a representative sample could not be collected due to the presence of low permeability soils. Soil gas concentrations of BTEX were at least two orders-of-magnitude below OSHA time-

weighted average (TWA) Permissible Exposure Levels (PELs) developed to be protective of on-site workers (NIOSH, 1994). In addition, no soil gas concentrations were detected greater than the TNRCC Effects Screening Levels for air (TNRCC, 1997a). Soil sample results (Exhibit E) collected near the AVGAS release location indicated no BTEX concentrations greater than TRNCC (1994) Plan A Heath-Based Soil Concentrations for Resident Ingestion and Inhalation. Although the ingestion and inhalation pathways are complete, the data indicate that exposure risk is minimal.

Current and/or future nearby residents could potentially be exposed to chemicals volatilizing from subsurface media via the inhalation pathway. No soils samples collected previously across the site have detected BTEX concentrations greater than TRNCC (1994) Plan A Heath-Based Soil Concentration for Resident Ingestion and Inhalation. In addition, because the TNRCC does not have ambient air risk-based criteria for these contaminants, the soil gas results discussed earlier were compared to USEPA Region III Risk-Based Concentrations for Ambient Air (USEPA, 1997). No BTEX concentrations were detected in soil gas greater than these criteria. Given these data and the fact that groundwater occurs at approximately 25 feet bgs, the exposure risk via volatilization of contaminants for current and/or future nearby residents is minimal.

The existence of off-Base potable water wells completed in the affected shallow aquifer suggests that future off-Base human receptors could potentially be exposed to site contaminants through ingestion or inhalation of, or dermal contact with, contaminants in groundwater extracted for potable use (USACE, 1991). The risk of future pathway completion is minimal, however, because the nearest shallow groundwater well is more than 0.5 mile from the site. Available data indicate that dissolved contaminants have migrated less than 300 feet in that direction and the areal extent does not appear to be increasing for contaminants with TNRCC clean-up criteria. In addition, fate and transport modeling (see the following section and Exhibit M for details) indicate that dissolved contaminants in groundwater will not migrate beyond the most downgradient monitoring wells which we located approximately 500 feet from the source areas.

Although numerous plant and wildlife species could be occupying areas on and near Randolph AFB, the absence of exposure pathways (e.g., no surface water impact and no shallow soils exposure due to pavement cover) indicates that no ecological receptors are likely to be exposed to contaminants.

Based on this evaluation of current and future receptors, the potential risk of exposure is minimal. This is also illustrated in the TNRCC decision flow charts which have been annotated with site-specific references (Figures 1 through 3).

PLUME STABILITY

Thirteen rounds of groundwater sampling have been completed at the BX Service Station between November 1990 and November 1997. Prior to the AVGAS release, groundwater sampling events indicated a contaminant plume which was not increasing in areal extent and was exhibiting a low static trend (i.e., groundwater concentrations not increasing significantly). Three monitoring wells near the UST source area (ST019MW071, ST019MW072, and ST019MW077) consistently exhibited benzene

concentrations above TNRCC Plan A Category II groundwater criteria prior to the second release (AVGAS) (the only compound detected above the criteria). Results of the most recent groundwater sampling event verify the previous data (Exhibits F and G). Natural attenuation parameters collected during the most recent sampling event exhibit trends associated with a plume which is being naturally degraded (Exhibits K and L). Because a limited source remains (over 475 cubic yards of contaminated soils were excavated during UST removal activities in 1996 [CCC Group, Inc., 1996]), this degradation will continually act to attenuate the dissolved contaminants in this area. In addition, assimilative capacity calculations provide in Exhibit L suggest that the shallow aquifer has the capacity to attenuate the existing contamination (see Exhibit L for explanation of assimilative capacity). Lastly, BIOSCREEN (AFCEE, 1997 [Version 1.4]) modeling of the historic releases has indicated that benzene should not migrate past the most downgradient wells at concentrations exceeding the target criteria and benzene concentrations should fall below the target criteria within 10 years throughout the plume (see Exhibit M for detail of BIOSCREEN modeling effort).

Because only two groundwater sampling events have occurred after the AVGAS release (and only one with the newly installed AVGAS release source well ST019MW260), the same assessment of current plume stability cannot be made with certainty. However, by evaluating the historic data and the recently collected data, the following points can be made:

1. The magnitude of the UST release is thought to have been much larger than that of the recent AVGAS release. Historic groundwater data indicates that the groundwater system attenuated the dissolved plume resulting from the UST release to a point where it is not increasing in areal extent and was exhibiting a low static trend.

2. Based on the recent soil sampling, minimal residual product remains in soils to continue to perpetrate the dissolved plume in groundwater. The pilot-scale bioventing system currently operating at the site should reduce contamination concentrations in any remaining source areas.

3. Based on the recent sampling, natural attenuation which will steadily degrade the groundwater contaminants is thought to be occurring.

4. Assimilative capacity calculations indicate that the aquifer has the ability to attenuate the dissolved contaminants. This is supported by the historic groundwater quality data.

5. Lastly, BIOSCREEN (AFCEE, 1997 [Version 1.4]) modeling of the AVGAS release indicates that benzene should not migrate past the most downgradient wells at concentrations exceeding the target criteria, and dissolved benzene concentrations should decrease below the TNRCC target criteria within 10 years throughout the plume (see Exhibit M for details of the BIOSCREEN modeling effort).

These points indicate that the extent to which the recent AVGAS release impacts the status of the BX Service Station is minimal considering the potential exposure risk discussed earlier and level of natural attenuation occurring. To confirm this, the Air

Force recommends that the BX Service Station petroleum release site be considered for closure contingent upon the completion of four more rounds of groundwater sampling and the continuation of the currently operating pilot-scale bioventing system for one year. Details of the contingency are provided in the following section.

CONTINGENCY

Contingency groundwater sampling is proposed by the Air Force to verify that the AVGAS release does not pose significant risk to potential receptors. Four additional groundwater sampling rounds are proposed over the next two years to confirm this. Table 1 summarizes the proposed sampling schedule. Upon completion of the sampling, the data will be evaluated to determine if the contaminant plume is not expanding in areal extent and is exhibiting a low static trend. Point of compliance wells (ST019MW075, ST019MW259, and ST019MW146) will be monitored to ensure dissolved contaminants due not migrate past the monitoring network. Assuming the plume does not expand in areal extent and is exhibiting a low static trend, a TNRCC-0030 Final Site Closure Report Form will be completed and submitted to the TNRCC for approval.

In addition to the groundwater sampling, continual operation of the pilot-scale bioventing system is proposed for one year to remove any residual soil contamination that may contribute to the dissolved plume. No confirmation sampling at the completion of the bioventing system operation is proposed due to the results of the most recent soil sampling event.

CONCLUSION

Given the low potential for current or future exposure to site contaminants, the historical groundwater data which indicates a contaminant plume that is not increasing in areal extent (UST release evidence), and the strong geochemical evidence that natural attenuation is occurring at the site, the BX Service Station is a candidate for closure according to TNRCC guidance. However, given the relatively recent nature of the AVGAS release and the absence of more than four post-release sampling rounds to verify plume stability, the Air Force proposes that the TNRCC grant closure to this site based on the contingency outlined above.

Available data indicates that dissolved benzene concentrations in groundwater are likely to remain above TNRCC Plan A Category II criteria near the two source areas for more than two years. Therefore, to support site closure, Randolph AFB proposes to restrict use of the shallow groundwater within 0.5 mile of the site through land use restrictions.

TABLE 1
GROUNDWATER SAMPLING CONTINGENCY
BX SERVICE STATION
RANDOLPH AFB, TEXAS

Location	Sampling Frequency	
	Semi-Annual (i.e., every round)	Annual (i.e., every two rounds)
ST019MW071	X	
ST019MW072		X
ST019MW073		X
ST019MW074	X	
ST019MW075	X	
ST019MW076		X
ST019MW077		X
ST019MW078	X	
ST019MW146	X	
ST019MW258	ABANDONED	
ST019MW259	X	
ST019MW260	X	

Notes:

1. Sampling will consist of measuring static water levels and sampling groundwater for BTEX and MTBE using USEPA Method SW8021B.
2. Sampling will continue for a minimum of four sampling events.

REFERENCES

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CCC Group, Inc. 1996. Underground Storage Tank Removal and Initial Site Assessment, Randolph Air Force Base AAFES Service Station. October.

National Institute for Occupational Safety and Health (NIOSH). 1994. Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services. June.

Parsons Engineering Science, Inc. (Parsons ES). 1997. Final Work Plan for the Risk-Based Investigation and Closure of the Base Exchange Service Station, Randolph Air Force Base, Texas.

Texas Natural Resources Conservation Commission (TNRCC). 1997a. Process for Closure Evaluation of Petroleum Hydrocarbon LPST Sites Exceeding Target Concentrations.

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TNRCC. 1997c. Memorandum - 1997 Effect Screening Levels List. September.

TNRCC. 1996. Leaking Petroleum Storage Tank (LPST) Closure Request Form.

TNRCC. 1994. Risk-Based Corrective Action for Leaking Underground Storage Tank (UST) Sites.

U.S. Army Corps of Engineers (USACE). 1991. Base Exchange Service Station Health Risk Analysis, Headquarters Air Training Command, Randolph Air Force Base, Texas. May.

U.S. Environmental Protection Agency (USEPA). 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities.

USEPA Region 3. 1997. Risk-Based Concentration Guidance. Letter from Eric W. Johnson, Ph.D., EPA Region 3 Senior Toxicologist. 22 December.

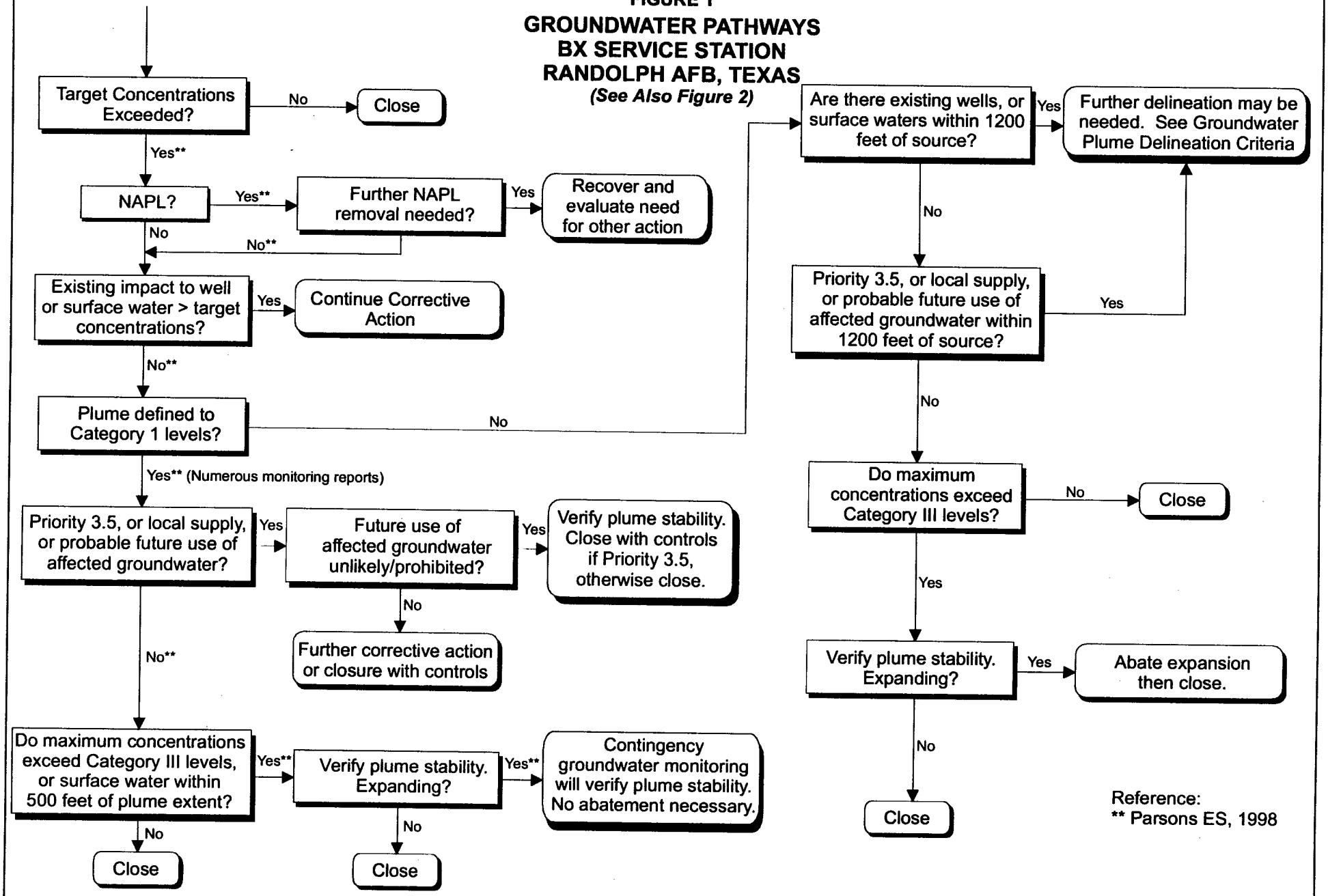
Versar, In. 1997. Memorandum - Free Product Recovery, AAFES Gas Station, Randolph AFB, TX. February.

Weston. 1997. Final Basewide Groundwater Assessment Report. August.

FIGURE 1

GROUNDWATER PATHWAYS
BX SERVICE STATION
RANDOLPH AFB, TEXAS

(See Also Figure 2)



Reference:
** Parsons ES, 1998

Source: TNRCC, 1997

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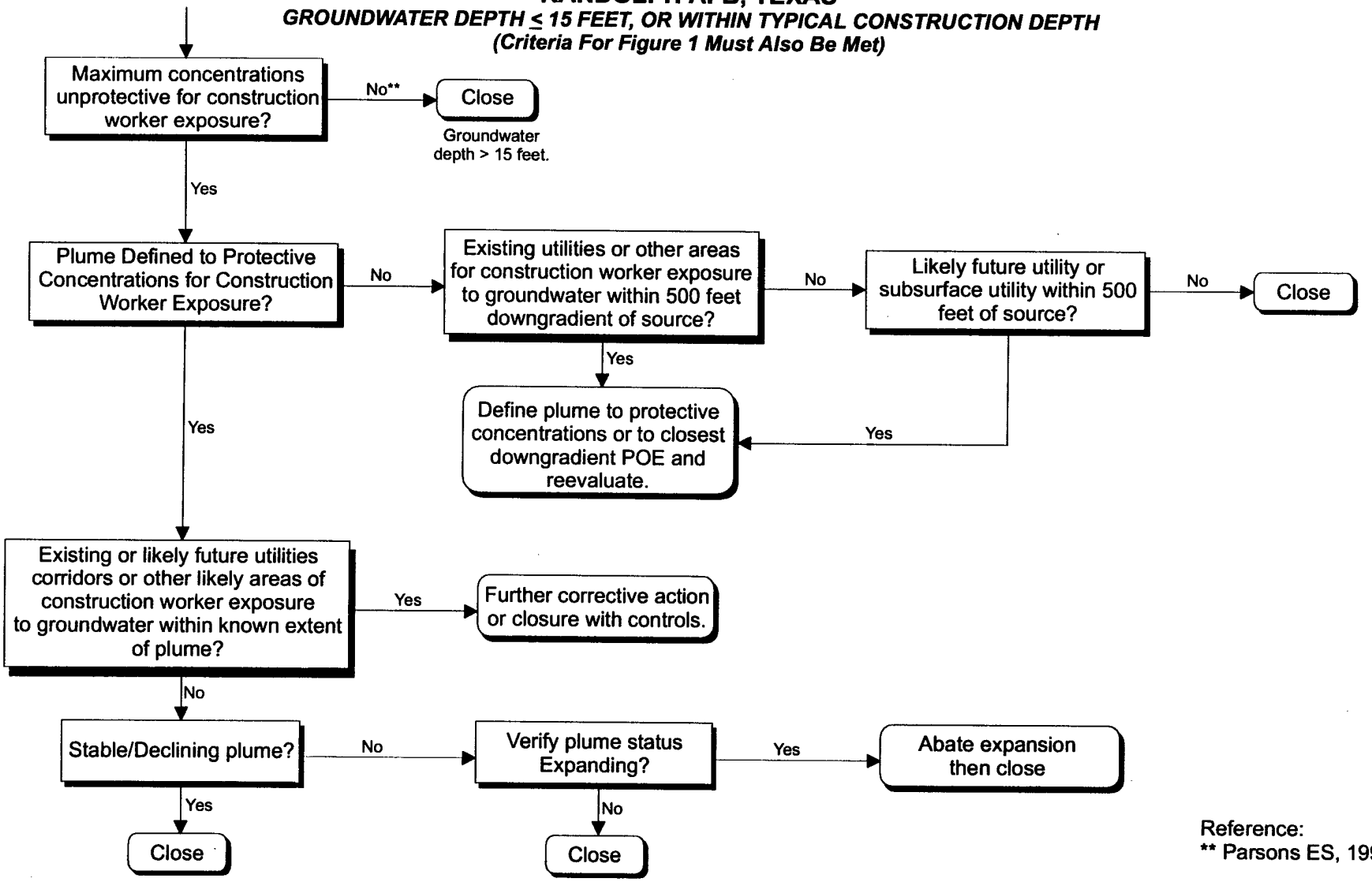
PARSONS ENGINEERING SCIENCE, INC.

FIGURE 2

GROUNDWATER PATHWAYS
BX SERVICE STATION
RANDOLPH AFB, TEXAS

GROUNDWATER DEPTH ≤ 15 FEET, OR WITHIN TYPICAL CONSTRUCTION DEPTH
(Criteria For Figure 1 Must Also Be Met)



Reference:
** Parsons ES, 1998

Source: TNRCC, 1997

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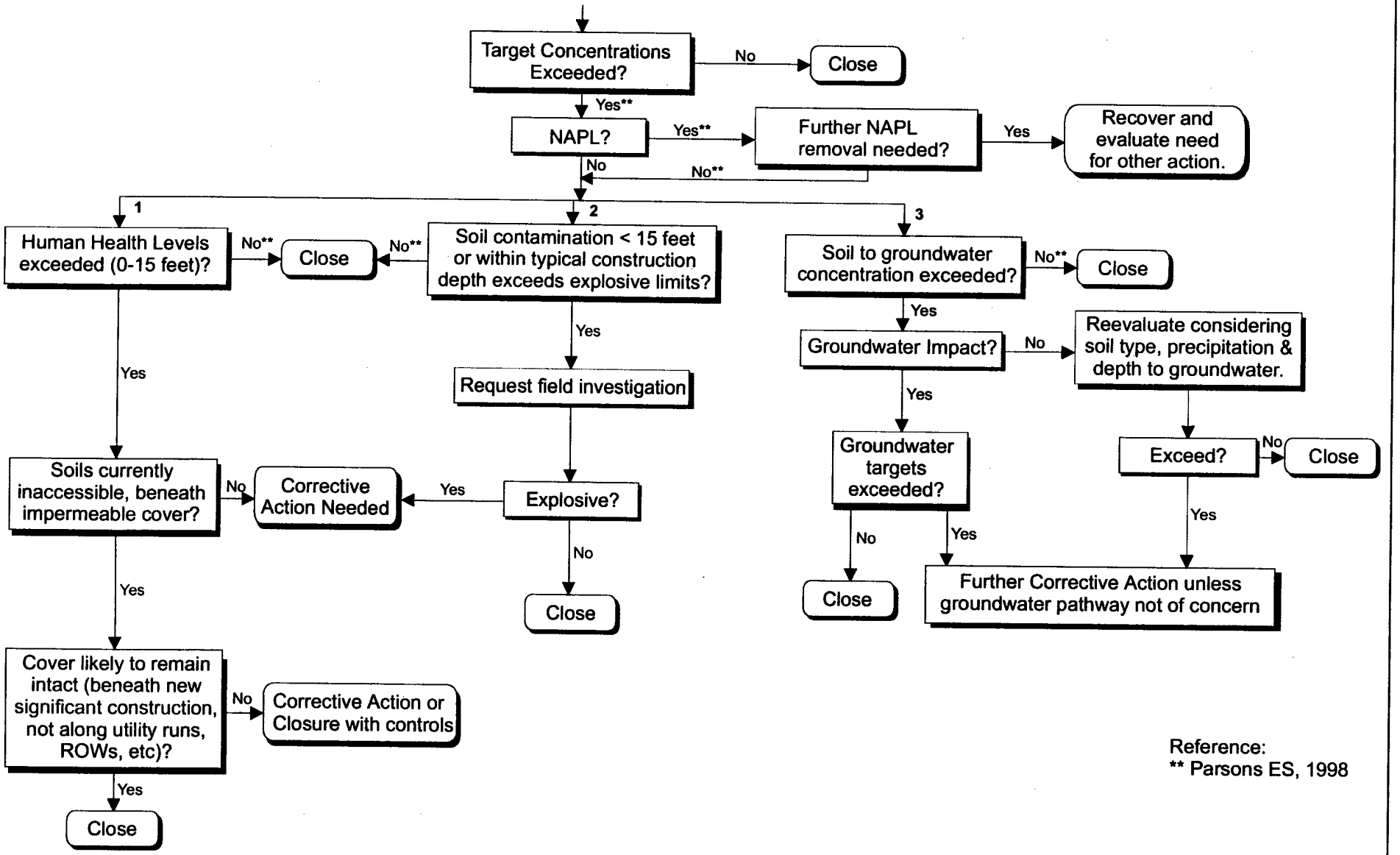
FIGURE 3

SOILS PATHWAYS
BX SERVICE STATION
RANDOLPH AFB, TEXAS

EVALUATE ALL THREE PATHWAYS



Reference:
** Parsons ES, 1998

Source: TNRCC, 1997

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Validation Qualifiers

The following definitions provide explanations of the USEPA (1994a and 1994b) qualifiers assigned to analytical results during data validation. The data qualifiers described were applied to both inorganic and organic results.

U - The analyte was analyzed for and is not present above the practical quantitation limit (PQL).

J - The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be considered as a basis for decision-making and are usable for many purposes.

J1 - The analyte is qualified as an estimated value solely because it is greater than the method detection limit (MDL) and less than the PQL indicating no laboratory quality issues.

UJ - The analyte analyzed for was not present above the reported PQL. The associated numerical value may not accurately or precisely represent the concentration necessary to detect the analyte in the sample.

R - The data are rejected as unusable for all purposes. This analyte was analyzed for, but the presence or absence of the analyte was not verified. Resampling and reanalysis are necessary to confirm the presence or absence of the analyte.

EXHIBIT A

SITE LAYOUT

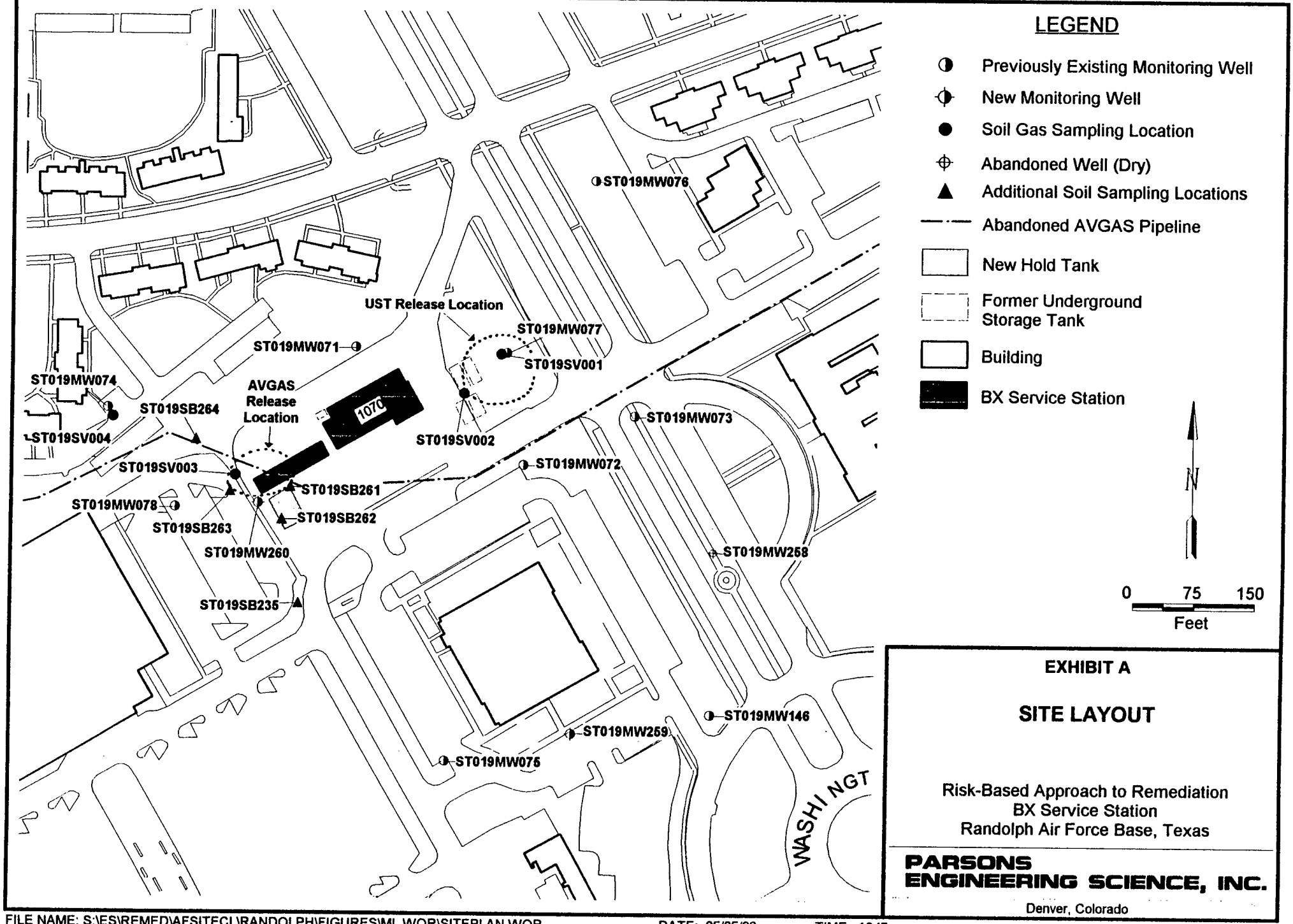


EXHIBIT A

SITE LAYOUT

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: S:\ES\REMED\AFSITECL\RANDOLPH\FIGURES\MI_WOR\SITEPLAN.WOR DATE: 05/05/98 TIME: 1045

EXHIBIT B

SOIL GAS RESULTS (11/97)

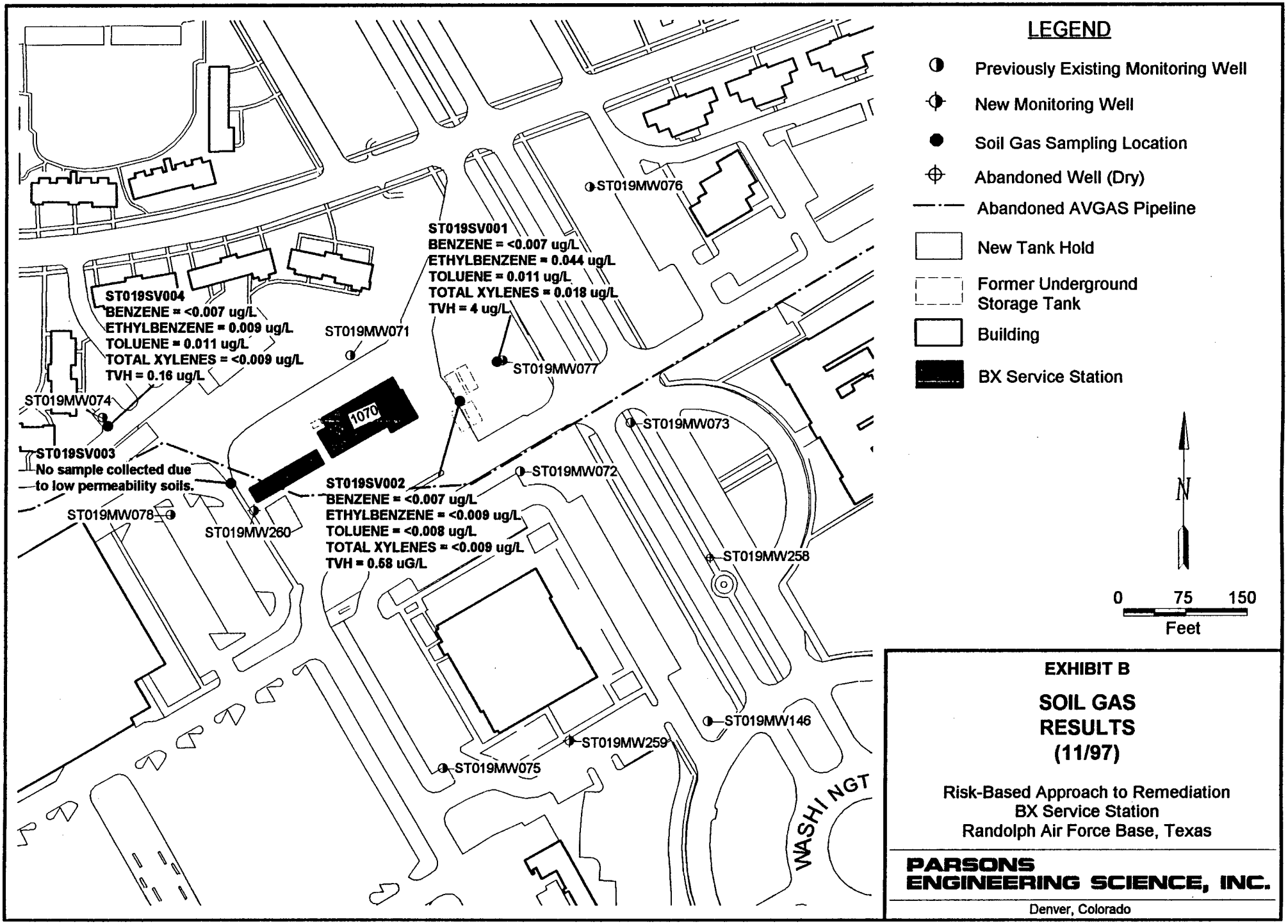


EXHIBIT B

SOIL GAS RESULTS (11/97)

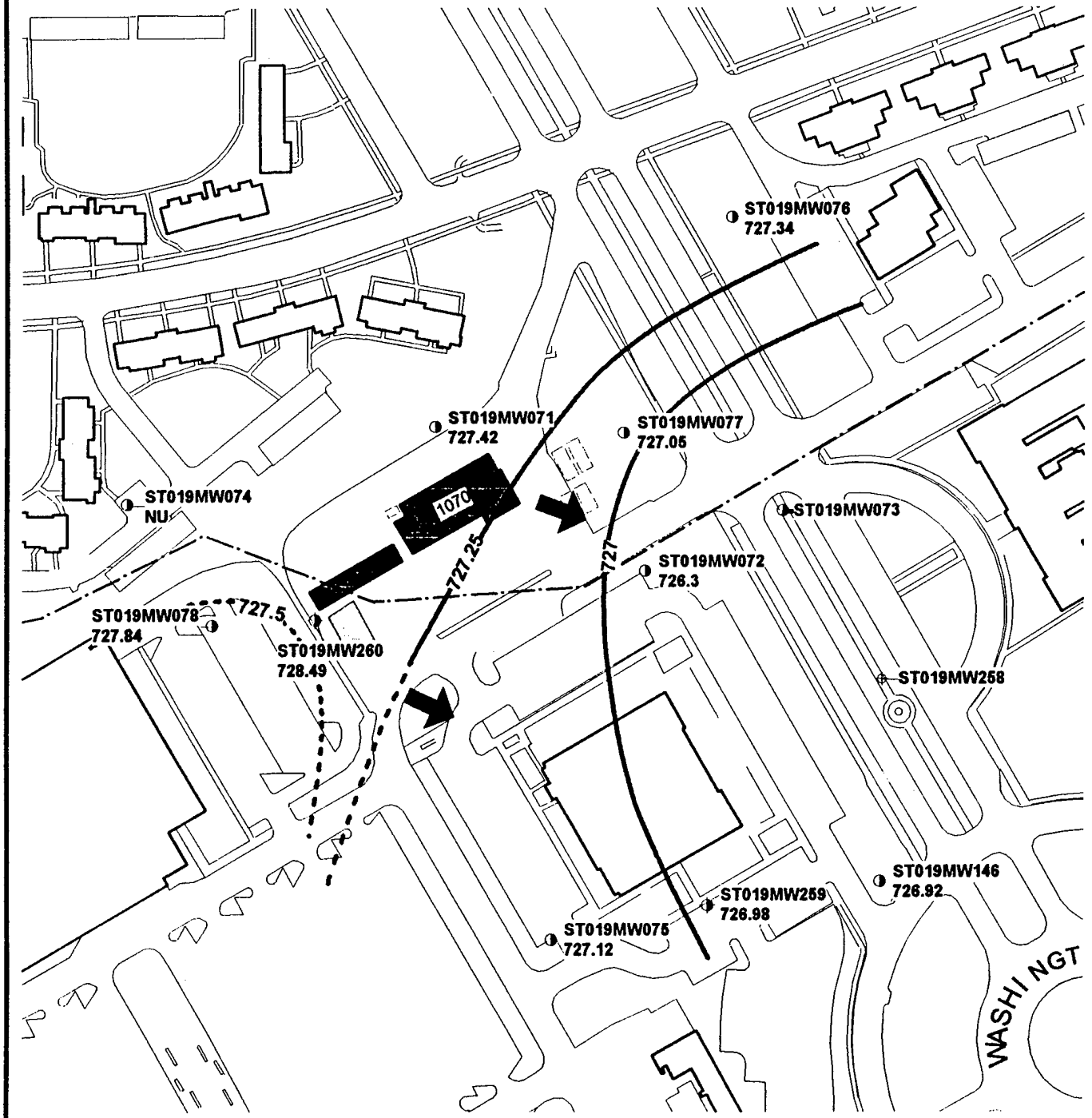
Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

EXHIBIT C

GROUNDWATER ELEVATION (1/6/98)



LEGEND

- Previously Existing Monitoring Well
- New Monitoring Well
- Abandoned Well (Dry)
- Inferred Line of Equal Groundwater Elevation (feet msl)
- Inferred Groundwater Flow Direction
- Abandoned AVGAS Pipeline
- New Tank Hold
- Former Underground Storage Tank
- Building
- BX Service Station

N

0 75 150
Feet

EXHIBIT C

GROUNDWATER ELEVATIONS (11/20/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: S:\ES\REMED\AFSITES\RANDOLPH\FIGURES\MLWORK\GWELEV.WOR DATE: 05/01/98 TIME: 1500

EXHIBIT D

AQUIFER PROPERTIES (11/97)

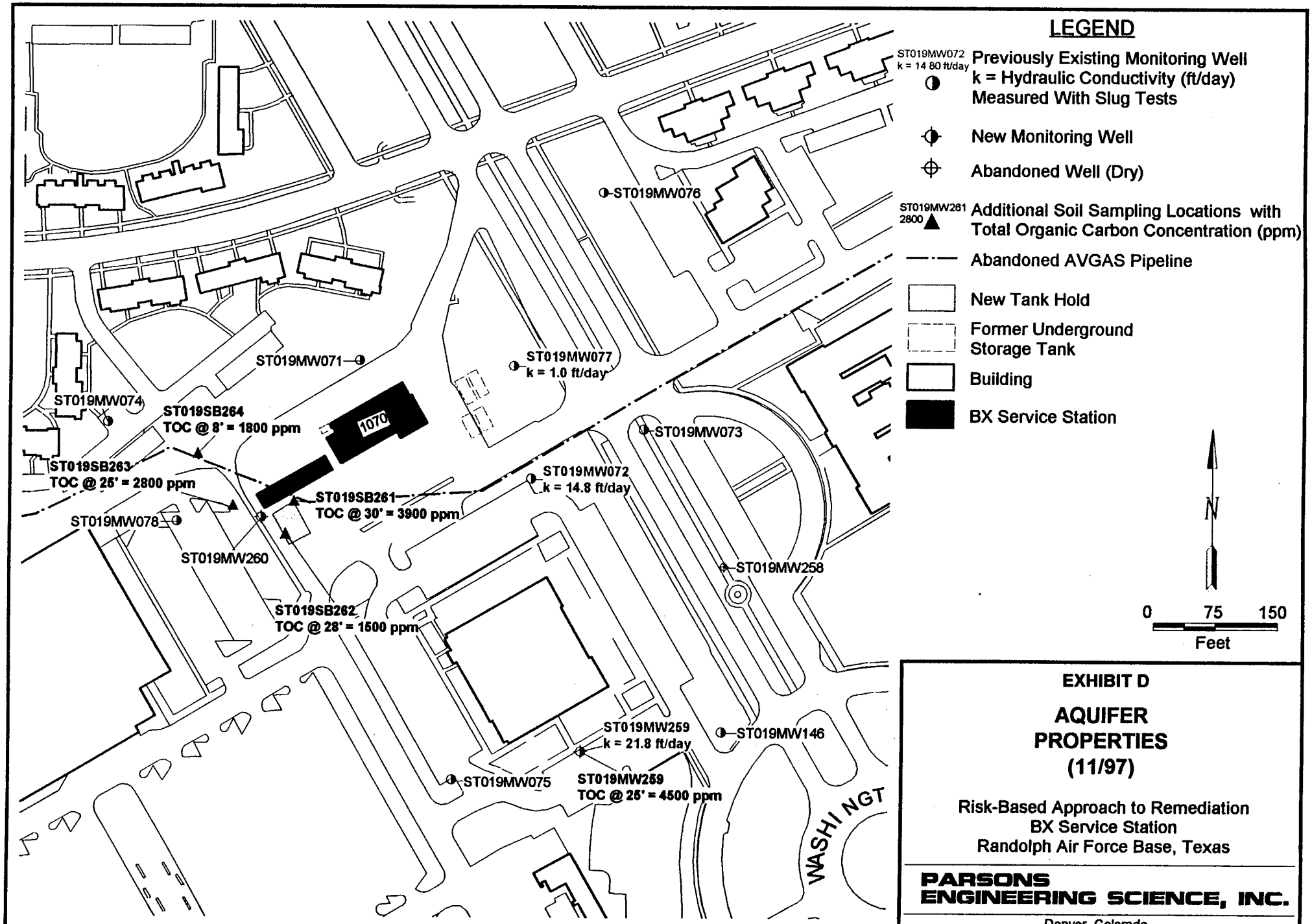


EXHIBIT D

AQUIFER PROPERTIES (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

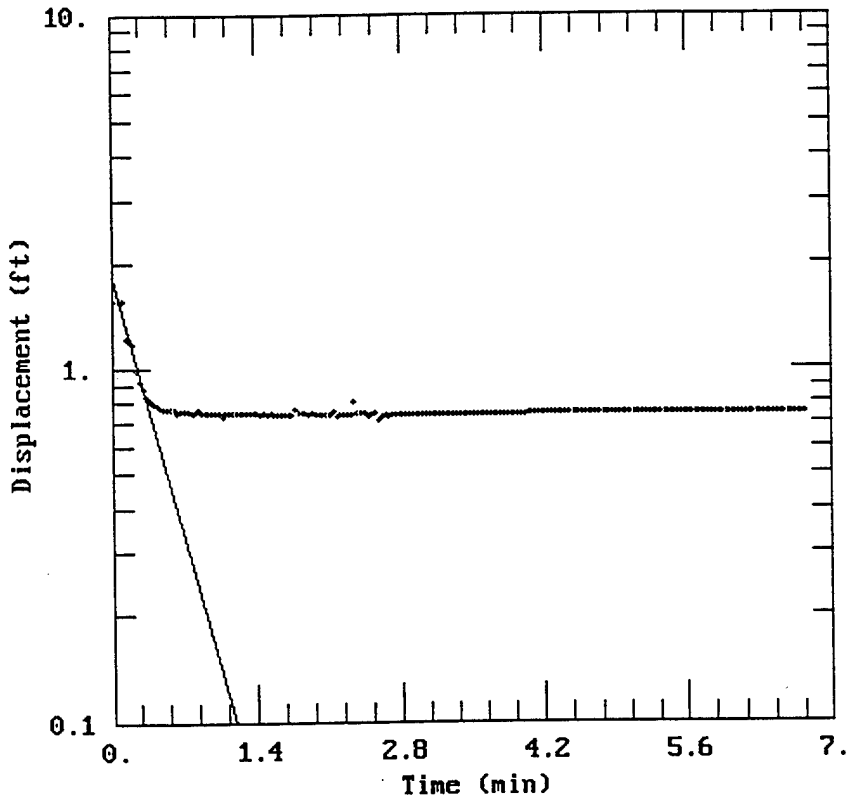
PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

FILE NAME: S:\ES\REMED\AFSITECL\RANDOLPH\FIGURES\MI WOR\SLUGTEST.WOR DATE: 05/14/98 TIME: 0750

CLIENT: AFCEE	COMPANY: Parsons Engineering Science
LOCATION: Randolph AFB - ST019	PROJECT: 731854

Falling Head Test #1 - ST019MW259



DATA SET:
RMW259F1.DAT
01/07/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1.55 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 6.49 ft
b = 6.49 ft
H = 6.49 ft

PARAMETER ESTIMATES:
K = 0.01631 ft/min
y0 = 1.804 ft

AQTESOLV

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A Q T E S O L V   R E S U L T S

Version 2.0

Developed by Glenn M. Duffield
(c) 1993, 1994 Geraghty & Miller, Inc.

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TEST DESCRIPTION

Data set........... RMW259F1.DAT
Output file........ RMW259F3.OUT
Data set title..... Falling Head Test #1 - ST019MW259
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW259

Units of Measurement
  Length.......... ft
  Time............ min

Test Well Data
  Initial displacement in well..... 1.55
  Radius of well casing............ 0.0833
  Radius of wellbore............... 0.2917
  Aquifer saturated thickness...... 6.49
  Well screen length............... 6.49
  Static height of water in well... 6.49
  Gravel pack porosity............. 0.3
  Effective well casing radius..... 0.1743
  Effective wellbore radius........ 0.2917
  Log(Re/Rw)....................... 2.832
  Constants A, B and C............. 0.000 , 0.000, 2.331
  No. of observations.............. 200

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

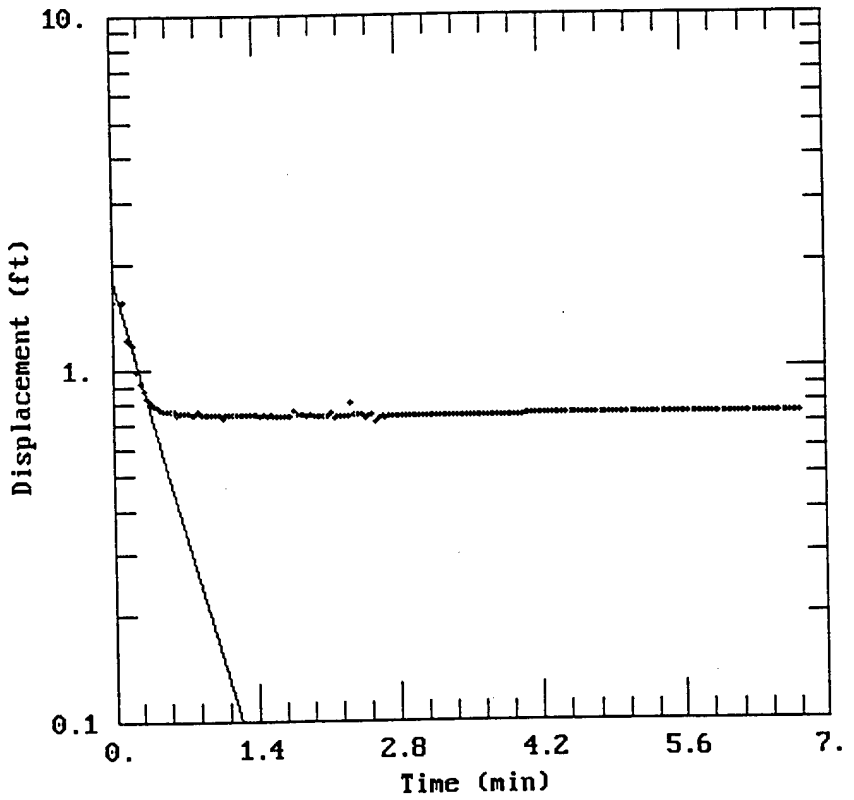
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.6311E-002 ft/min
y0 =	1.8044E+000 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

LIENT: AFCEE	COMPANY: Parsons Engineering Science
OCATION: Randolph AFB - ST019	PROJECT: 731854

Falling Head Test #1 - ST019MW259



DATA SET:
RMW259F1.DAT
01/27/98

AQUIFER MODEL:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1.55 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 6.49 ft
b = 6.49 ft
H = 6.49 ft

PARAMETER ESTIMATES:
K = 0.0127 ft/min
y0 = 1.771 ft

AQTESOLV

```
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                         A Q T E S O L V   R E S U L T S
                                   Version 2.0

                          Developed by Glenn M. Duffield
                     (c) 1993, 1994 Geraghty & Miller, Inc.

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Data set title..... Falling Head Test #1 - ST019MW259
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW259

Units of Measurement
   Length.......... ft
   Time............ min

Test Well Data
   Initial displacement in well..... 1.55
   Radius of well casing............ 0.0833
   Radius of wellbore............... 0.2917
   Aquifer saturated thickness...... 6.49
   Well screen length............... 6.49
   Static height of water in well... 6.49
   Gravel pack porosity............. 0.3
   Effective well casing radius..... 0.1743
   Effective wellbore radius........ 0.2917
   Log(Re/Rw)....................... 2.313
   Constants A, B and C............. 0.000 ,   0.000,   1.729
   No. of observations.............. 200

================================================================================
                               ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                       RESULTS FROM VISUAL CURVE MATCHING

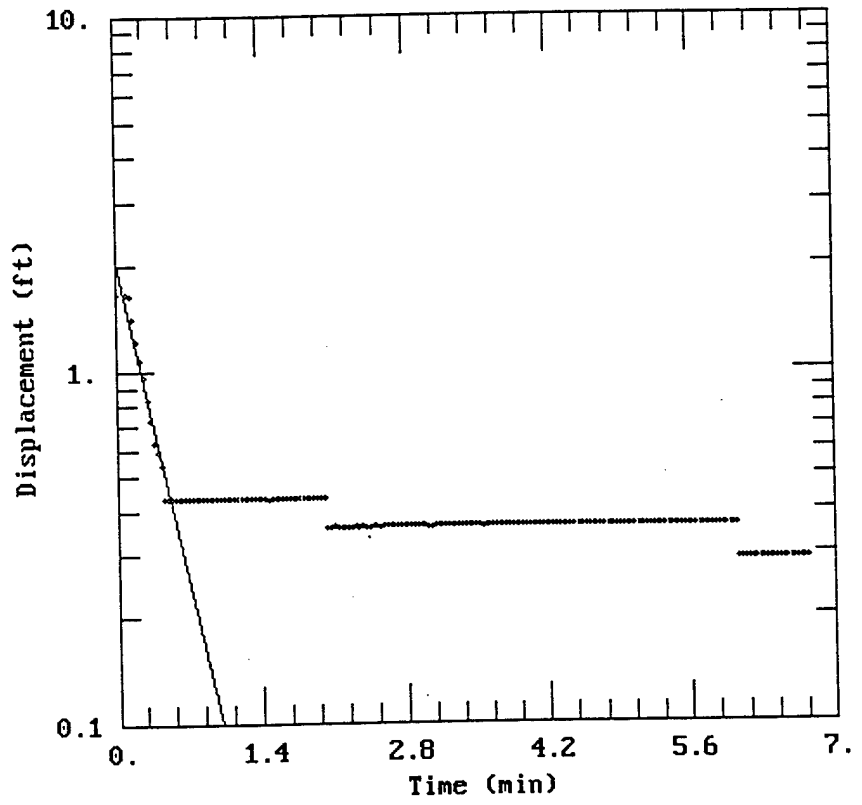

VISUAL MATCH PARAMETER ESTIMATES

          Estimate
   K  =   1.2704E-002 ft/min
   y0 =   1.7705E+000 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

CLIENT: AFCEE	COMPANY: Parsons Engineering Science
LOCATION: Randolph AFB - ST019	PROJECT: 731854

Falling Head Test #2 - ST019MW259



DATA SET:
RMW259F2.DAT
01/09/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1.645 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 6.49 ft
b = 6.49 ft
H = 6.49 ft

PARAMETER ESTIMATES:
K = 0.01648 ft/min
y0 = 2.035 ft

AQTESOLV

```
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                         A Q T E S O L V   R E S U L T S
                                   Version 2.0

                         Developed by Glenn M. Duffield
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                                  TEST DESCRIPTION

Data set........... RMW259F2.DAT
Output file........ RMW259F2.OUT
Data set title..... Falling Head Test #2 - ST019MW259
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW259

Units of Measurement
   Length.......... ft
   Time............ min

Test Well Data
   Initial displacement in well..... 1.645
   Radius of well casing............ 0.0833
   Radius of wellbore............... 0.2917
   Aquifer saturated thickness...... 6.49
   Well screen length............... 6.49
   Static height of water in well... 6.49
   Gravel pack porosity............. 0.3
   Effective well casing radius..... 0.1743
   Effective wellbore radius........ 0.2917
   Log(Re/Rw)....................... 2.313
   Constants A, B and C............. 0.000 ,   0.000,   1.729
   No. of observations.............. 200

====================================================================================
                                  ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

====================================================================================
                          RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K   =   1.6478E-002 ft/min
   y0  =   2.0351E+000 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
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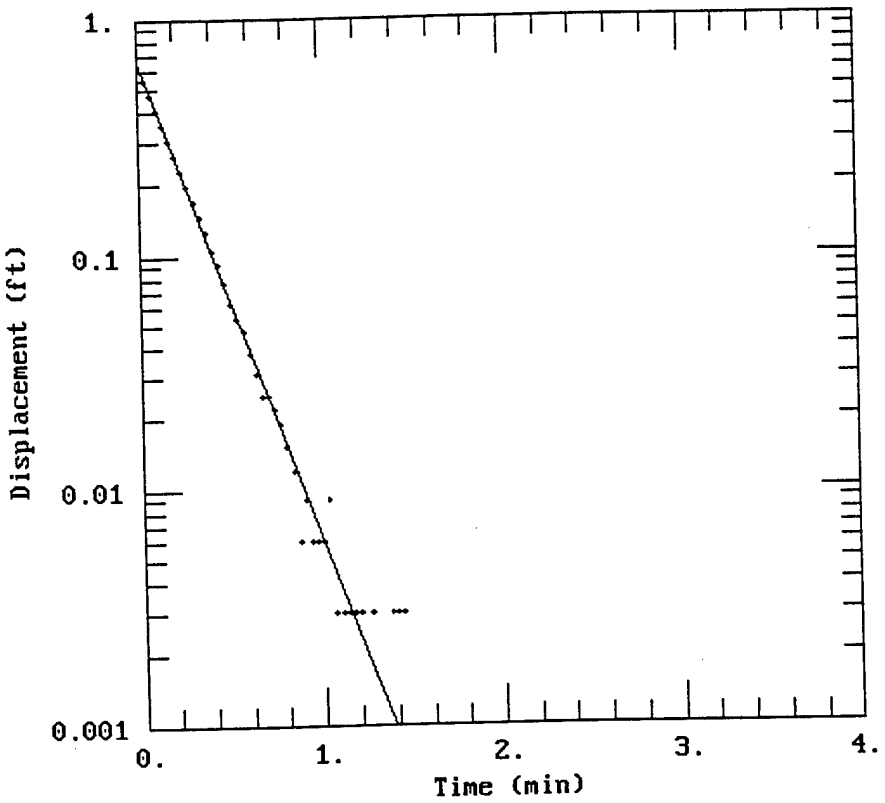
CLIENT: AFCEE	COMPANY: Parsons Engineering Science
LOCATION: Randolph AFB - ST019	PROJECT: 731854

Rising Head Test #1 - ST019MW072



DATA SET:
RMW72R1.DAT
01/06/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 0.547 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 10. ft
b = 10.45 ft
H = 10.45 ft

PARAMETER ESTIMATES:
K = 0.01937 ft/min
y0 = 0.6566 ft

AQTESOLV

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>

A Q T E S O L V   R E S U L T S

Version 2.0

Developed by Glenn M. Duffield

1/06/98 16:28:28

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TEST DESCRIPTION

Data set........... RMW72R1.DAT
Output file........ RMW72R1.OUT
Data set title..... Rising Head Test #1 - ST019MW072
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW072

Units of Measurement
Length.......... ft
Time............ min

Test Well Data
Initial displacement in well..... 0.547
Radius of well casing............ 0.0833
Radius of wellbore............... 0.2917
Aquifer saturated thickness...... 10.45
Well screen length............... 10
Static height of water in well... 10.45
Gravel pack porosity............. 0.3
Effective well casing radius..... 0.1743
Effective wellbore radius........ 0.2917
Log(Re/Rw)....................... 2.711
Constants A, B and C............. 0.000 , 0.000, 2.107
No. of observations.............. 40

===

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

===

RESULTS FROM VISUAL CURVE MATCHING

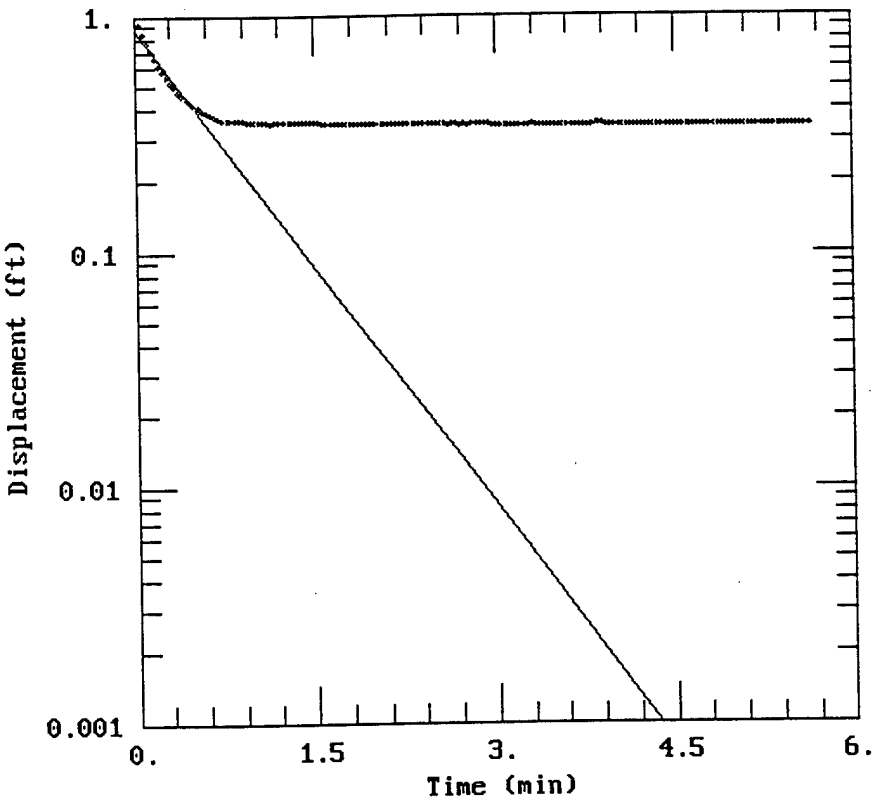
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.9367E-002 ft/min
y0 =	6.5663E-001 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

CLIENT: AFCEE	COMPANY: Parsons Engineering Science
LOCATION: Randolph AFB - ST019	PROJECT: 731854

Rising Head Test #2 - ST019MW072



DATA SET:
RMW72R2.DAT
01/06/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 0.913 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 10. ft
b = 10.45 ft
H = 10.45 ft

PARAMETER ESTIMATES:
K = 0.006398 ft/min
y0 = 0.8733 ft

AQTESOLV

```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

                       A Q T E S O L V    R E S U L T S
                                  Version 2.0

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1/06/98                                                                16:37:04

================================================================================
                              TEST DESCRIPTION

Data set........... RMW72R2.DAT
Output file........ RMW72R2.OUT
Data set title..... Rising Head Test #2 - ST019MW072
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW072

Units of Measurement
   Length.......... ft
   Time............ min

Test Well Data
   Initial displacement in well..... 0.913
   Radius of well casing............ 0.0833
   Radius of wellbore............... 0.2917
   Aquifer saturated thickness...... 10.45
   Well screen length............... 10
   Static height of water in well... 10.45
   Gravel pack porosity............. 0.3
   Effective well casing radius..... 0.1743
   Effective wellbore radius........ 0.2917
   Log(Re/Rw)....................... 2.711
   Constants A, B and C............. 0.000 ,   0.000,   2.107
   No. of observations.............. 169

================================================================================
                              ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                      RESULTS FROM VISUAL CURVE MATCHING

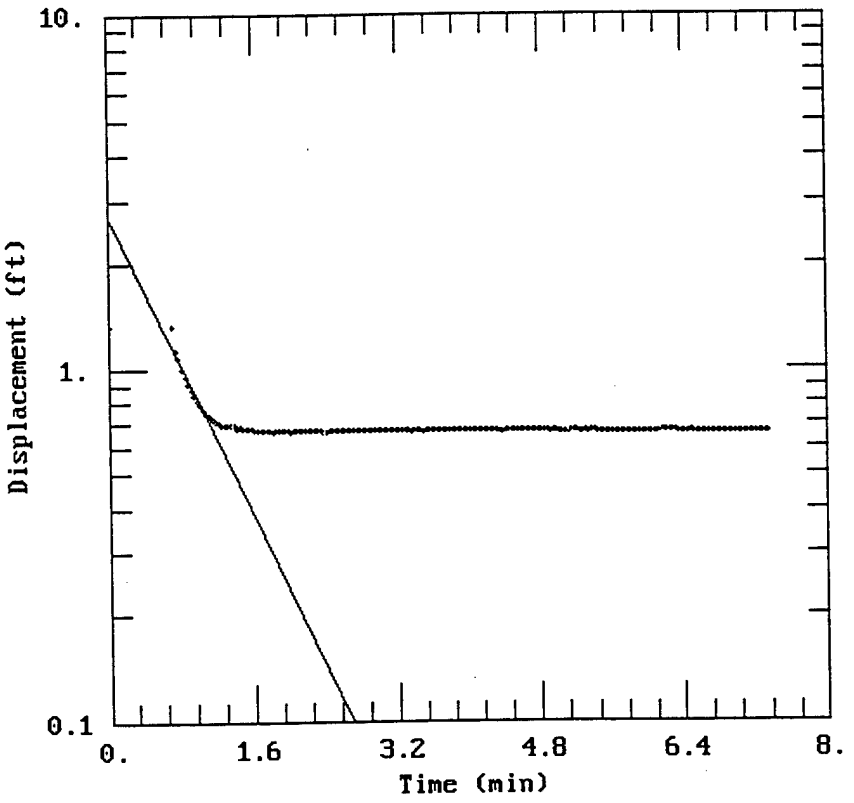
VISUAL MATCH PARAMETER ESTIMATES

             Estimate
   K  =    6.3980E-003 ft/min
   y0 =    8.7330E-001 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

LIENT: AFCEE	COMPANY: Parsons Engineering Science
OCATION: Randolph AFB - ST019	PROJECT: 731854

Falling Head Test #1 - ST019MW072



DATA SET:
RMW72F1.DAT
01/06/98

AQUIFER MODEL:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1.324 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 10. ft
b = 10.45 ft
H = 10.45 ft

PARAMETER ESTIMATES:
K = 0.005072 ft/min
y0 = 2.698 ft

AQTESOLV

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

A Q T E S O L V   R E S U L T S

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1/06/98 15:52:56

==

TEST DESCRIPTION

Data set........... RMW72F1.DAT
utput file........ RMW72F1.OUT
ata set title..... Falling Head Test #1 - ST019MW072
Company............ Parsons Engineering Science
roject............ 731854
lient............. AFCEE
ocation........... Randolph AFB - ST019
Test date.......... 11/15/97
est well.......... ST019MW072

Units of Measurement
Length.......... ft
Time............ min

Test Well Data
Initial displacement in well..... 1.324
Radius of well casing........... 0.0833
Radius of wellbore.............. 0.2917
Aquifer saturated thickness...... 10.45
Well screen length.............. 10
Static height of water in well... 10.45
Gravel pack porosity............ 0.3
Effective well casing radius..... 0.1743
Effective wellbore radius........ 0.2917
Log(Re/Rw)..................... 2.711
Constants A, B and C............ 0.000 , 0.000, 2.107
No. of observations............. 200

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

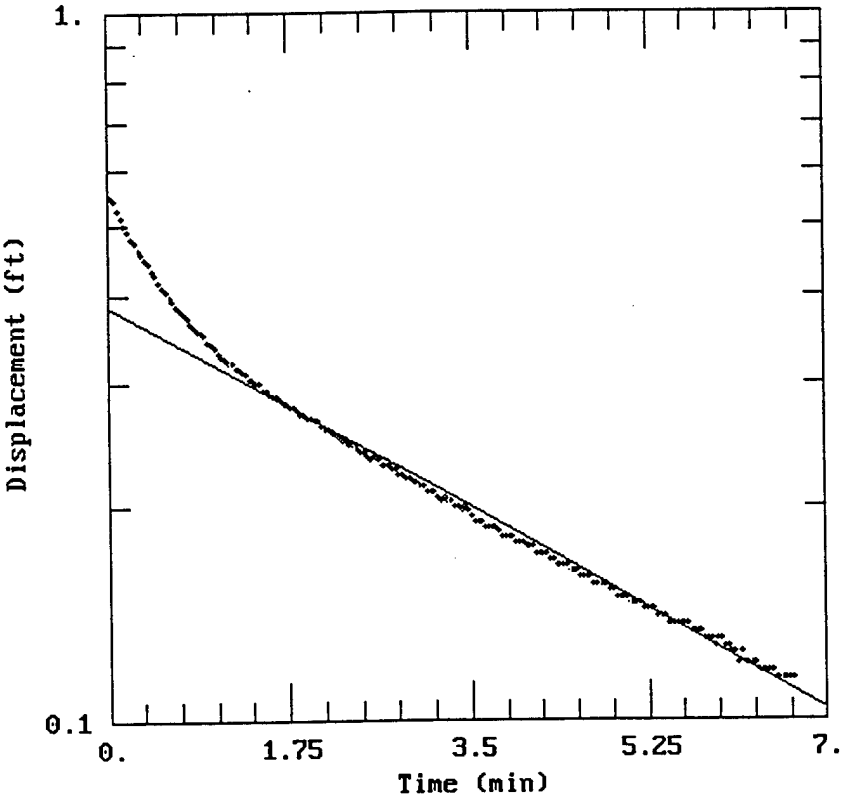
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	5.0723E-003 ft/min
y0 =	2.6977E+000 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

CLIENT: AFCEE	COMPANY: Parsons Engineering Science
LOCATION: Randolph AFB - ST019	PROJECT: 731854

Rising Head Test #1 - ST019MW077



DATA SET:
RMW77R1.DAT
01/26/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 0.55 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 11.96 ft
b = 11.96 ft
H = 11.96 ft

PARAMETER ESTIMATES:
K = 0.0006776 ft/min
y0 = 0.3858 ft

AQTESOLV

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>

A Q T E S O L V   R E S U L T S
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1/06/98 16:28:28

==

TEST DESCRIPTION

Data set........... RMW72R1.DAT
Output file........ RMW72R1.OUT
Data set title..... Rising Head Test #1 - ST019MW072
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW072

Units of Measurement
Length.......... ft
Time............ min

Test Well Data
Initial displacement in well..... 0.547
Radius of well casing............ 0.0833
Radius of wellbore............... 0.2917
Aquifer saturated thickness...... 10.45
Well screen length............... 10
Static height of water in well... 10.45
Gravel pack porosity............. 0.3
Effective well casing radius..... 0.1743
Effective wellbore radius........ 0.2917
Log(Re/Rw)....................... 2.711
Constants A, B and C............. 0.000 , 0.000, 2.107
No. of observations.............. 40

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

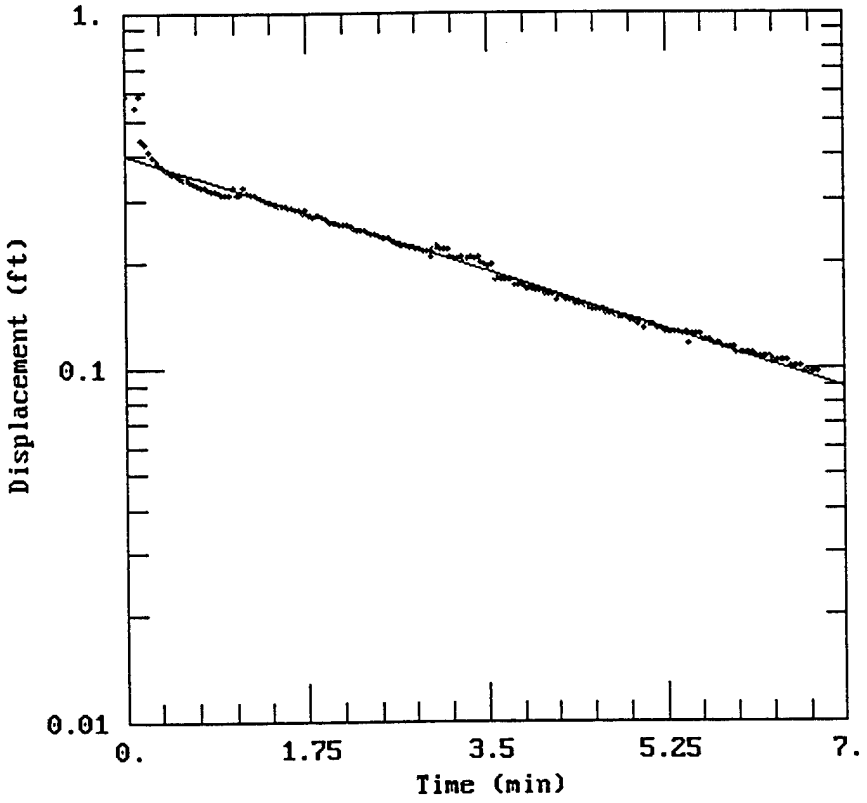
VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.9367E-002 ft/min
y0 =	6.5663E-001 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>

CLIENT: AFCEE	COMPANY: Parsons Engineering Science
LOCATION: Randolph AFB - ST019	PROJECT: 731854

Falling Head Test #1 - ST019MW077



DATA SET:
RMW77F1
01/26/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 0.588 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 11.96 ft
b = 11.96 ft
H = 11.96 ft

PARAMETER ESTIMATES:
K = 0.0007777 ft/min
y0 = 0.4022 ft

AQTESOLV

```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

                       A Q T E S O L V   R E S U L T S
                                 Version 2.0

                        Developed by Glenn M. Duffield
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1/26/98                                                                        16:03:02

===========================================================================================
                                  TEST DESCRIPTION

Data set........... RMW77F1
Output file........ RMW77F1.OUT
Data set title..... Falling Head Test #1 - ST019MW077
Company............ Parsons Engineering Science
Project............ 731854
Client............. AFCEE
Location........... Randolph AFB - ST019
Test date.......... 11/15/97
Test well.......... ST019MW077

Units of Measurement
   Length.......... ft
   Time............ min

Test Well Data
   Initial displacement in well..... 0.588
   Radius of well casing............ 0.0833
   Radius of wellbore............... 0.2917
   Aquifer saturated thickness...... 11.96
   Well screen length............... 11.96
   Static height of water in well... 11.96
   Gravel pack porosity............. 0.3
   Effective well casing radius..... 0.1743
   Effective wellbore radius........ 0.2917
   Log(Re/Rw)....................... 2.832
   Constants A, B and C............. 0.000 ,   0.000,   2.331
   No. of observations.............. 200

===========================================================================================
                                  ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

===========================================================================================
                         RESULTS FROM VISUAL CURVE MATCHING

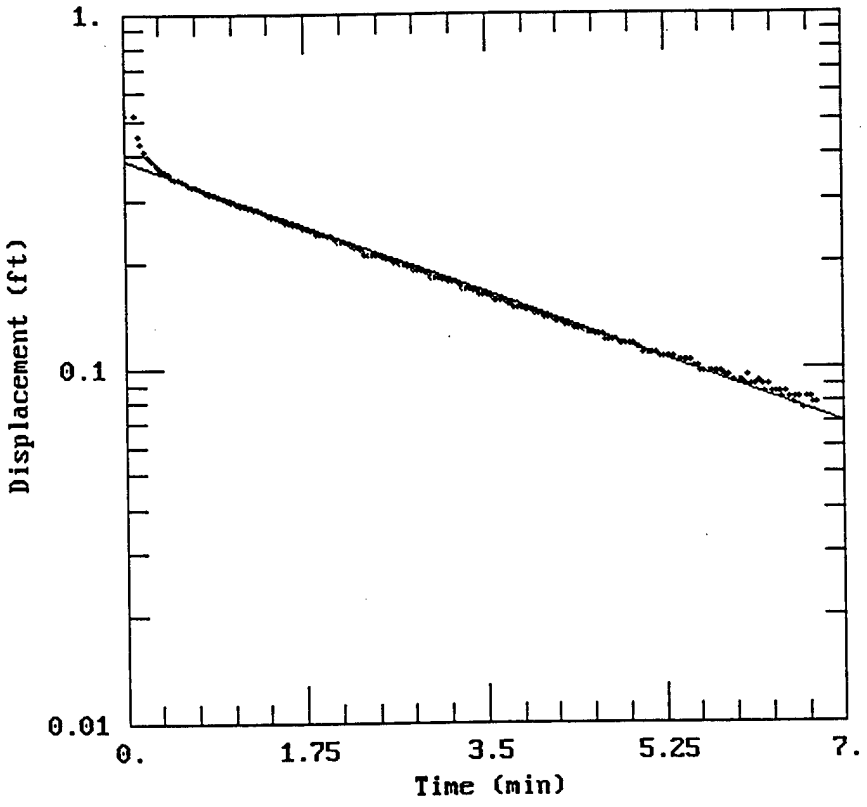
VISUAL MATCH PARAMETER ESTIMATES

          Estimate
   K  =   7.7771E-004 ft/min
   y0 =   4.0217E-001 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

LIENT: AFCEE	COMPANY: Parsons Engineering Science
OCATION: Randolph AFB - ST019	PROJECT: 731854

Falling Head Test #2 - ST019MW077



DATA SET:
RMW77F2.DAT
01/26/98

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 0.518 ft
r_c= 0.0833 ft
r_w= 0.2917 ft
L = 11.96 ft
b = 11.96 ft
H = 11.96 ft

PARAMETER ESTIMATES:
K = 0.0008728 ft/min
y0 = 0.3845 ft

AQTESOLV

```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

                    A Q T E S O L V   R E S U L T S
                             Version 2.0

                     Developed by Glenn M. Duffield
                 (c) 1993, 1994 Geraghty & Miller, Inc.

/26/98                                                              17:44:35

=================================================================================
                              TEST DESCRIPTION

Data set........... RMW77F2.DAT
tput file........ RMW77F2.OUT
ta set title..... Falling Head Test #2 - ST019MW077
Company............ Parsons Engineering Science
roject............ 731854
ient............. AFCEE
cation........... Randolph AFB - ST019
Test date.......... 11/15/97
est well.......... ST019MW077

Units of Measurement
   Length.......... ft
   Time............ min

Test Well Data
   Initial displacement in well..... 0.518
   Radius of well casing............ 0.0833
   Radius of wellbore............... 0.2917
   Aquifer saturated thickness...... 11.96
   Well screen length............... 11.96
   Static height of water in well... 11.96
   Gravel pack porosity............. 0.3
   Effective well casing radius..... 0.1743
   Effective wellbore radius........ 0.2917
   Log(Re/Rw)....................... 2.832
   Constants A, B and C............. 0.000 ,   0.000,   2.331
   No. of observations.............. 200

=================================================================================
                              ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

=================================================================================
                      RESULTS FROM VISUAL CURVE MATCHING


VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   8.7276E-004 ft/min
   y0 =   3.8454E-001 ft

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

EXHIBIT E

SOIL SAMPLING RESULTS (11/97)

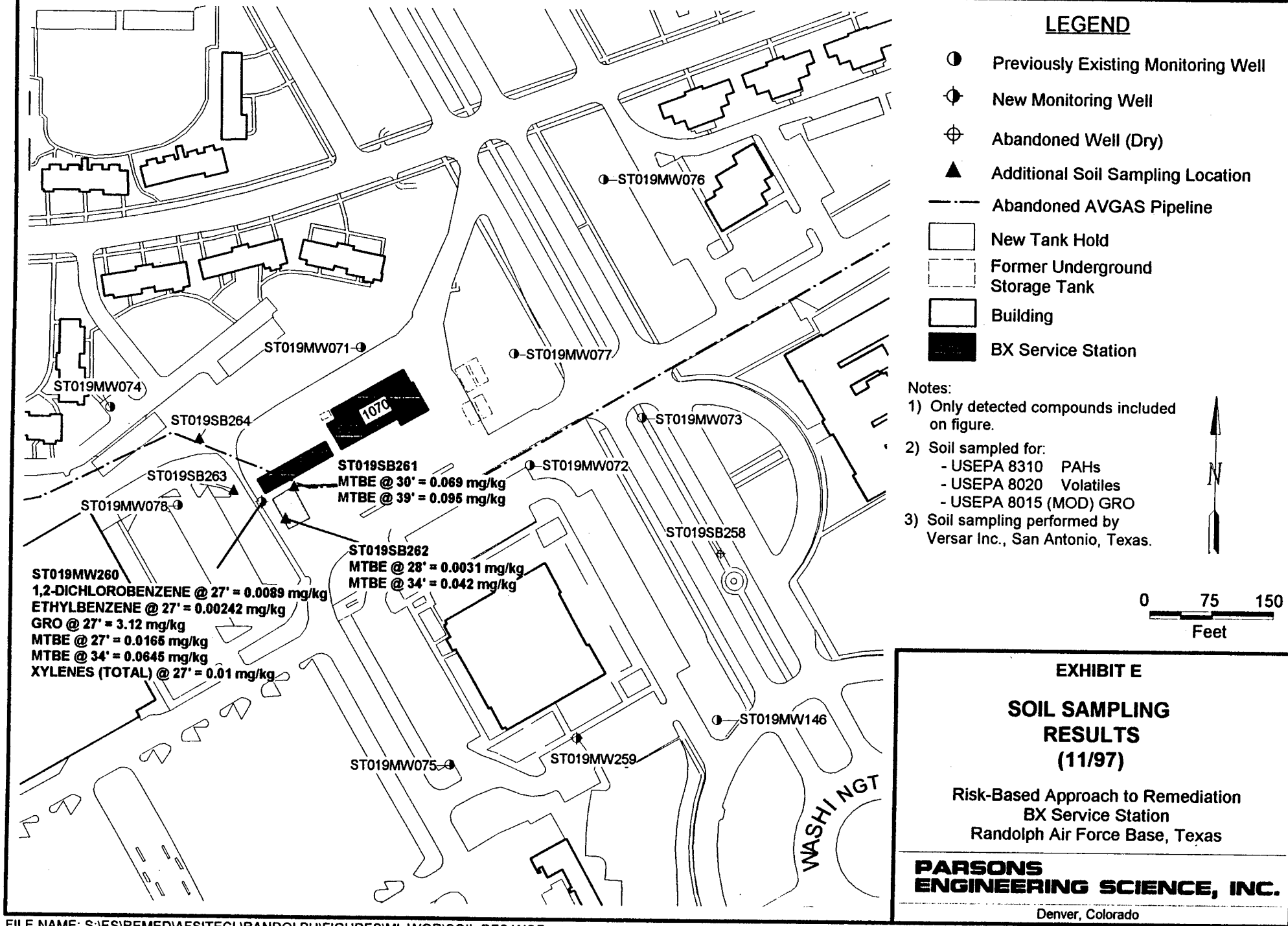


EXHIBIT E

SOIL SAMPLING RESULTS (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: S:\FS\REMED\AFSITECL\RANDOLPH\FIGURES\MI WOR\SOIL-RES.WOR DATE: 05/01/98 TIME: 1320

EXHIBIT F

BENZENE IN GROUNDWATER (11/97)

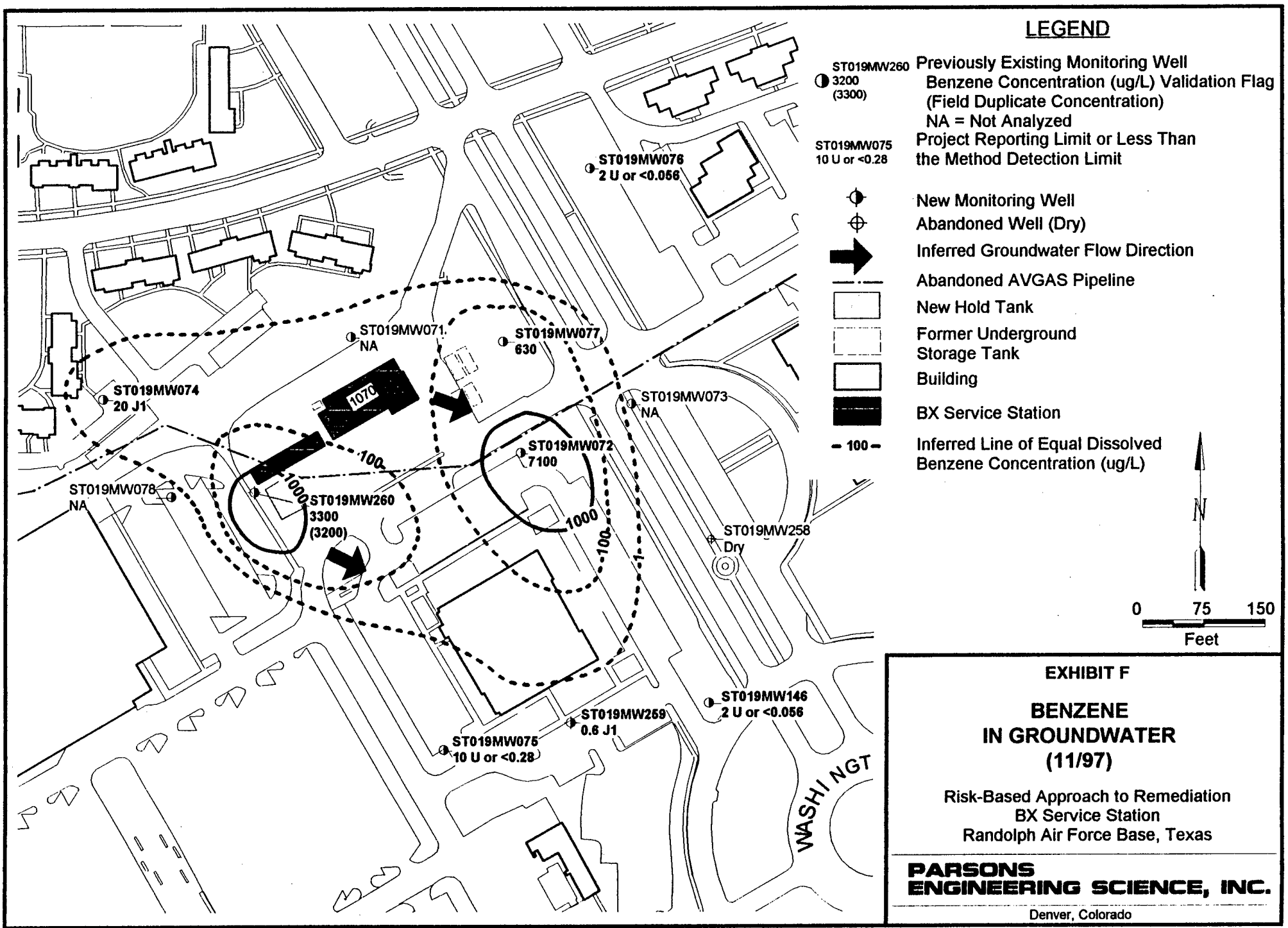


EXHIBIT F

BENZENE IN GROUNDWATER (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

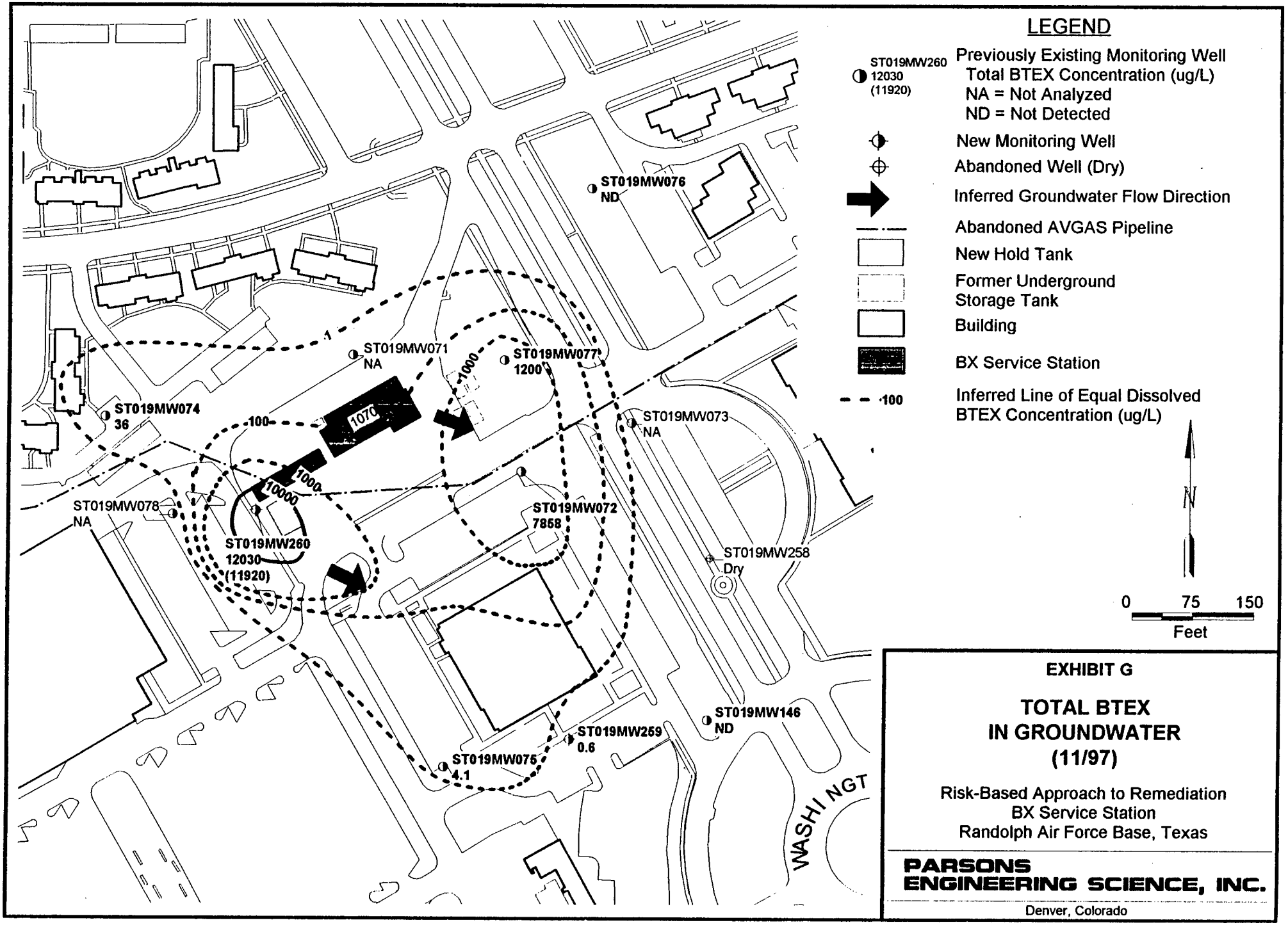
PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

FILE NAME: S:\ES\REMED\AFSITES\RANDOLPH\FIGURES\ML WOR\BENZENE.WOR DATE: 05/05/98 TIME: 1100

EXHIBIT G

TOTAL BTEX IN GROUNDWATER (11/97)



LEGEND

- ST019MW260 / 12030 / (11920) — Previously Existing Monitoring Well; Total BTEX Concentration (ug/L); NA = Not Analyzed; ND = Not Detected
- New Monitoring Well
- Abandoned Well (Dry)
- Inferred Groundwater Flow Direction
- Abandoned AVGAS Pipeline
- New Hold Tank
- Former Underground Storage Tank
- Building
- BX Service Station
- 100 — Inferred Line of Equal Dissolved BTEX Concentration (ug/L)

N

0 75 150
Feet

EXHIBIT G

TOTAL BTEX IN GROUNDWATER (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

EXHIBIT H

MTBE IN GROUNDWATER (11/97)

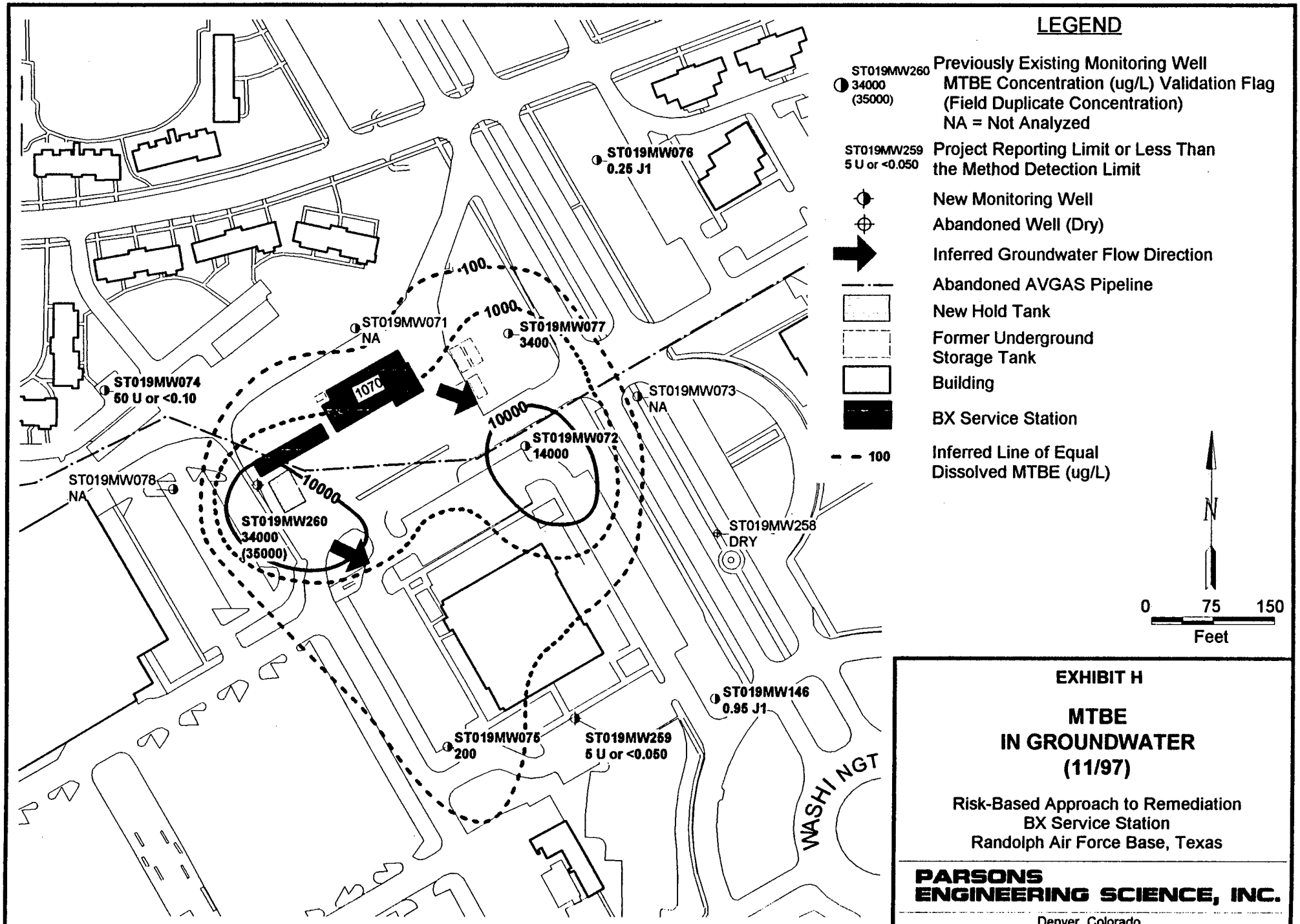


EXHIBIT H

MTBE IN GROUNDWATER (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

FILE NAME: S:\ES\REMED\AFSITECI\RANDOLPH\FIGURES\MI_WOR\MTBE.WOR DATE: 05/05/98 TIME: 1110

EXHIBIT I

TOTAL LEAD IN GROUNDWATER (11/97)

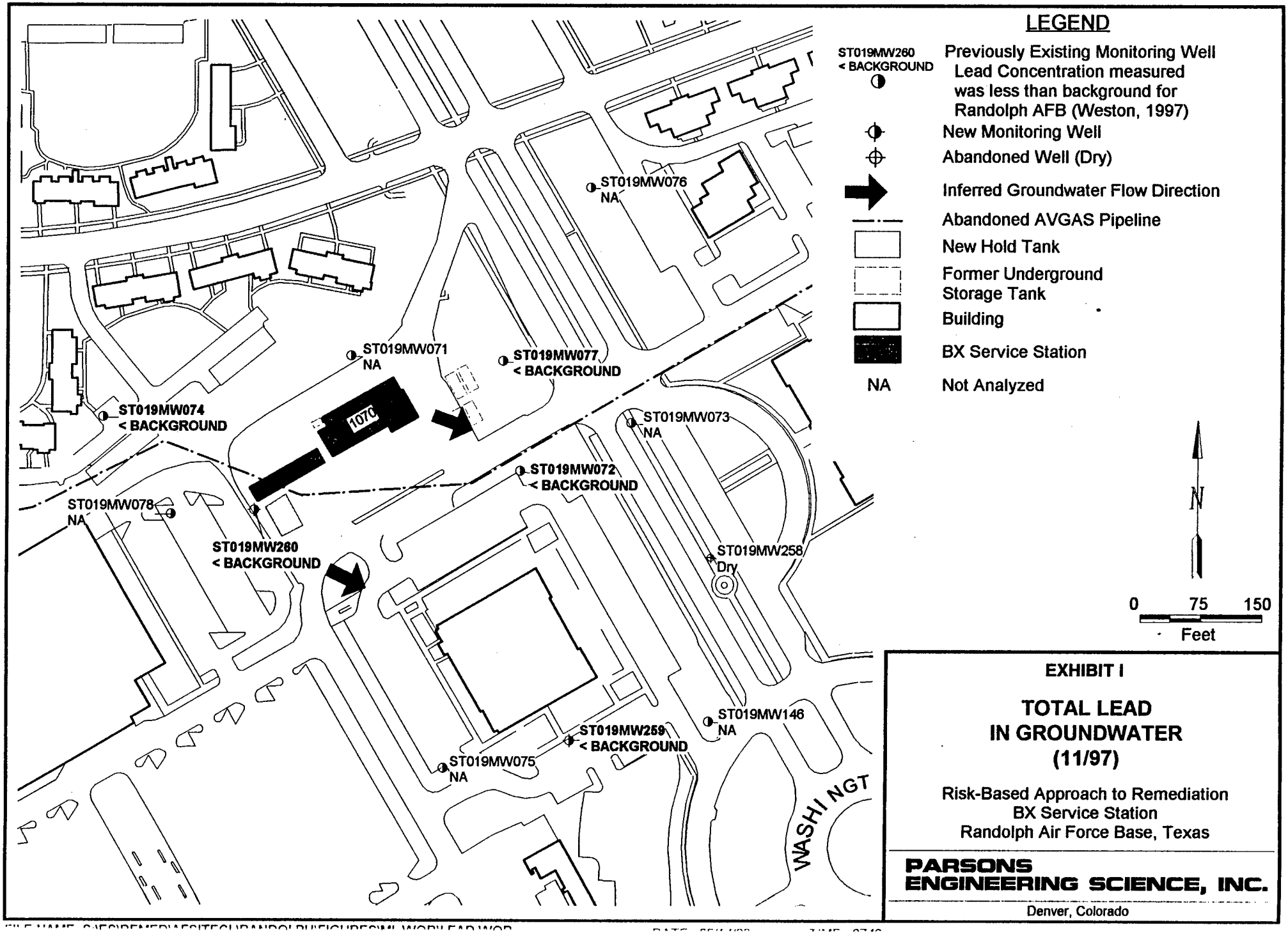


EXHIBIT I

TOTAL LEAD IN GROUNDWATER (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

EXHIBIT J

PNAS AND TVH DETECTED IN GROUNDWATER (11/97)

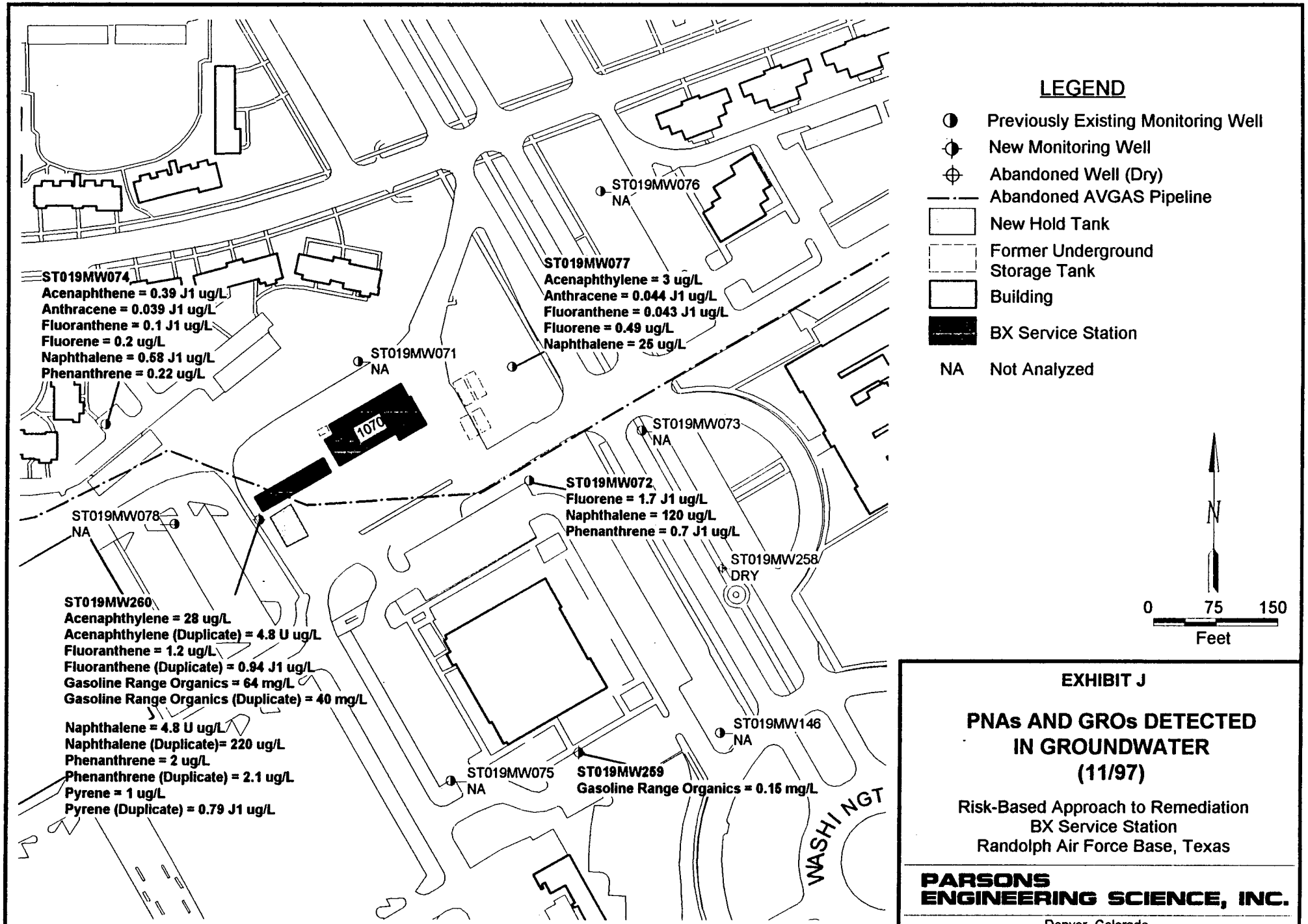


EXHIBIT J

PNAs AND GROs DETECTED IN GROUNDWATER (11/97)

Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

FILE NAME: S:\ES\REMED\AFSITECL\RANDOLPH\FIGURES\MI_WOR\PNA-TVH.WOR DATE: 05/01/98 TIME: 1555

EXHIBIT K

GEOCHEMICAL PARAMETERS IN GROUNDWATER (11/97)

EXHIBIT K
GEOCHEMICAL PARAMETERS FOR GROUNDWATER
(11/97)
Risk-Based Approach to Remediation
BX Service Station
Randolph Air Force Base, Texas

Location	Location with Respect to Groundwater Contamination Plume	Date Sampled	Temp (°C)	pH	DO (mg/L)[a/]	Redox (mV)[b/]	Ferrous Iron (mg/L)	Sulfate (mg/L)	Manganese (mg/L)	Methane (µg/L)[c/]	Nitrate plus Nitrite as N (mg/L)	Total BTEX (µg/L)
ST019MW076	Cross-Gradient	11/12/97	21.4	6.5	3.7	161.2	ND[d/]	76.7	0.4	1.7	3.2	ND
ST019MW074	Upgradient-Inside Plume	11/12/97	23.2	6	1.81	-181.4	4.28	22.1	0.2	8000	0.16	36
ST019MW072	Inside Plume	11/13/97	24.3	6	2.2	-146	6.44	ND	0.4	0.18 U[e/]	0.019 J1[f/]	7,858
ST019MW077	Inside Plume	11/12/97	21.8	NA[g/]	1.86	-181.3	5.8	ND	0.6	77	0.1 U	1,200
ST019MW260	Inside Plume	11/16/97	24.6	6	2.57	-86.2	ND	ND	ND	15	0.14	12,030
ST019MW259	Downgradient Edge	11/15/97	21.2	6.5	2.27	-138.2	0.77	73.4	0.1	680	0.22	4.1
ST019MW075	Downgradient Inside MTBE Plume	11/12/97	23.7	6.5	1.8	42.1	0.83	67.8	0.9	0.18 U	1.1	0.6
ST019MW146	Downgradient	11/12/97	23	7.5	2.5	137.6	0.21	17.8	ND	3100	4.3	ND

[a/] mg/L = milligrams per liter.

[b/] mV = millivolts.

[c/] µg/L = micrograms per liter.

[d/] ND = Not detected.

[e/] U = Analyte not detected above the associated practical reporting limit.

[f/] J1 = Estimated value above method detection limit and below practical reporting limit.

[g/] NA = Not analyzed.

EXHIBIT L

EXPRESSED ASSIMILATIVE CAPACITY

EXHIBIT L

EXPRESSED ASSIMILATIVE CAPACITY

Mass-balance relationships can be used to determine how much contaminant mass can be degraded by each of the redox reactions that microorganisms might use to make free energy available for cell maintenance and production. The stoichiometric relationship between the contaminant and the electron acceptor can be used to estimate the expressed assimilative capacity of the groundwater. Once the redox reactions operating at these sites were defined, it is possible to estimate theoretically how much contaminant mass can be assimilated or oxidized by available electron acceptors. This analysis provides a basis for determining the potential for continued contaminant mass reduction in saturated media at the site.

A closed system with 2 liters of water can be used to help visualize the physical meaning of assimilative capacity. Assume that the first liter contains no fuel hydrocarbons, but it contains fuel degrading microorganisms and has an assimilative capacity (i.e., electron acceptors) of exactly "*x*" µg of fuel hydrocarbons based on stoichiometry. The second liter has no assimilative capacity; however, it contains fuel hydrocarbons. As long as these 2 liters of water are kept separate, biodegradation of the fuel hydrocarbons will not occur. If these 2 liters are combined in a closed system, biodegradation will commence and continue until the fuel hydrocarbons are depleted or the electron acceptors are depleted. Assuming a nonlethal environment, if fewer than "*x*" µg of fuel hydrocarbons were in the second liter, all of the fuel hydrocarbons would eventually degrade given a sufficient time; likewise, if greater than "x" µg of fuel hydrocarbons were in the second liter of water, only "*x*" µg of fuel hydrocarbons would ultimately degrade.

The November 1997 groundwater samples were analyzed for a number geochemical parameters. Site groundwater data for DO suggest that natural attenuation of hydrocarbons in the shallow aquifer is occurring by aerobic biodegradation. In addition, data for nitrate/nitrite, ferrous iron, sulfate, and methane suggest that anaerobic degradation via denitrification, iron reduction, sulfate reduction, and methanogenesis is occurring. On the basis of the stoichiometry of the various biodegradation reactions and the observed concentration of electron acceptors in background (upgradient) groundwater (ST019MW076), and in the plume core (wells ST019MW072 and ST019MW260), the expressed assimilative capacity of groundwater at the BX Service Station is at least 19,950 µg/L for BTEX or 20,440 µg/L for benzene alone using ST019MW072 as the plume core well. Using ST019MW260 as the plume core well estimates the assimilative capacity to be 12,690 µg/L for BTEX or 12,990 µg/L for benzene alone (Table L.1).

TABLE L.1
EXPRESSED ASSIMILATIVE CAPACITY OF SITE GROUNDWATER

BX SERVICE STATION

RANDOLPH AFB, TEXAS

Electron Acceptor or Process	ST019MW072 PLUME CORE WELL		ST019MW260 PLUME CORE WELL	
	Expressed BTEX Assimilative Capacity (µg/L)	Expressed Benzene Assimilative Capacity (µg/L)	Expressed BTEX Assimilative Capacity (µg/L)	Expressed Benzene Assimilative Capacity (µg/L)
Aerobic Respiration	480	490	360	370
Denitrification	2,870	2,950	2,870	2,950
Maganese Reduction	negligible	negligible	40	40
Iron Reduction	300	300	negligible	negligible
Sulfate Reduction	16,300	16,700	9,400	9,610
Methanogenesis	negligible	negligible	18	18
Expressed Assimilative Capacity	19,950	20,440	12,690	12,990
Maximum BTEX Concentration (11/97)	12,030	-	12,030	-
Maximum Benzene Concentration (11/97)	-	7,100	-	7,100

The groundwater beneath the BX Service Station is an open system, which continually receives additional electron receptors from upgradient and from the percolation of precipitation. This means that the assimilative capacity is not fixed as it is in a closed system, and therefore cannot be compared directly to contaminant concentrations in the groundwater. Rather, the expressed assimilative capacity of groundwater is intended to serve as a qualitative tool. The expressed assimilative capacities at this site computed using either plume core well are greater than the highest measured total BTEX concentration measured in November 1997 (12,030 µg/L) and the highest measured benzene concentration measured in November 1997 (7,100 µg/L). The differences between the assimilative capacities computed for the two plume areas most likely are due to the relatively new nature of the AVGAS release (i.e., ST019MW260 location). This can be seen by evaluating individual expressed assimilative capacities which suggests that sulfate reduction near the new release is not yet occurring at the rate it is at the old release. These significant expressed assimilative capacities are strong indicators that biodegradation is occurring and is sufficient to limit migration of the dissolved BTEX.

EXHIBIT M

BIOSCREEN® RESULTS

EXHIBIT M

BIOSCREEN® MODEL

M.1 MODEL DESCRIPTION

BIOSCREEN® is a screening model which simulates remediation by natural attenuation of dissolved hydrocarbons at petroleum fuel release sites (Newell *et al*, 1996). The software is based on the Domenico (1987) analytical solute transport model and is designed to simulate advection, dispersion, adsorption, and aerobic decay as well as anaerobic reactions that have been shown to be the dominant biodegradation processes at many petroleum release sites. BIOSCREEN® includes three different model types:

1) Solute transport without decay;

2) Solute transport with biodegradation modeled as a first-order decay process (simple, lumped parameter approach); and

Solute transport with biodegradation modeled as an "instantaneous" biodegradation reaction.

The first model is appropriate for predicting the movement of conservative (non-degrading) solutes such as chloride. The only attenuation mechanisms simulated are dispersion in the longitudinal, transverse, and vertical directions and adsorption of the contaminant to the soil matrix.

With the second model, the solute degradation rate is proportional to the solute concentration. This is a conventional method for simulating biodegradation in dissolved hydrocarbon plumes. With this method, dispersion, sorption, and biodegradation parameters are lumped together in a single calibration parameter. The first-order decay model does not account for site-specific information such as the availability of electron acceptors. In addition, it does not assume any biodegradation of dissolved constituents in the source zone. In other words, this model assumes that biodegradation starts immediately downgradient of the source and that it does not decrease the concentrations of dissolved organic compounds in the source zone itself.

First-order expressions may not be accurate for describing biodegradation of organic contaminants in groundwater because electron acceptor limitations are not considered. A more accurate prediction of biodegradation effects may be realized by incorporating the instantaneous reaction equation into a transport model (Newell *et al.*, 1996).

At almost all petroleum release sites, biodegradation is present and can be verified by demonstrating the consumption of aerobic and anaerobic electron acceptors. Therefore, results from the No Biodegradation model are intended only to be used for comparison purposes and to demonstrate the effects of biodegradation on plume migration. The Instantaneous Reaction model is recommended either alone or in

addition to the First-Order Decay model for most sites where electron acceptor and metabolic byproduct concentration data have been collected.

M.2 MODELING OBJECTIVES

The BIOSCREEN® modeling was performed for the BX Service Station site to accomplish the following two objectives:

- To estimate the maximum migration distance of the benzene plume from the source area over time,
- To estimate the time required for benzene concentrations in the plume to be attenuated to below the groundwater quality standard, and
- To determine whether benzene will migrate to compliance wells at concentrations above the groundwater quality standard.

M.3 CONCEPTUAL MODEL DESIGN AND LIMITING ASSUMPTIONS

BIOSCREEN® has the following limitations:

- As an analytical model, BIOSCREEN® assumes simple groundwater flow conditions; and
- As a screening tool, BIOSCREEN® only approximates the more complicated processes that occur in the field.

Because the model is not capable of simulating a complicated flow regime, the hydraulic input parameters of the site were based on field data from the primary contaminant flow pathway of the site. A seven-year calibration simulation was run using the dissolved contaminant data collected in November 1990 (Weston, 1995) as the starting point. Because the site is dominated by methane production, it was assumed that benzene will degrade last and that the dissolved material at the edge of the plume is primarily benzene (Newell *et al.*, 1996). Therefore, benzene was the contaminant modeled.

M.4 INITIAL MODEL INPUT DATA

Input data for the BIOSCREEN® model are used to calculate groundwater velocity, contaminant plume dispersivity, a contaminant retardation coefficient, a contaminant decay coefficient, dissolved contaminant concentrations in the source area, a half-life of the contaminant source, and the dimensions of the source zone. Each of these input values is described in more detail below and summarized in Table M.1.

M.4.1 Groundwater Velocity

The advective groundwater velocity beneath the site is based on site specific hydraulic conductivity and hydraulic gradient data and an estimated effective porosity of 25 percent based on published values for sand and gravel (Spitz and Moreno, 1996). The hydraulic conductivity value used in the model (7.8×10^{-3} cm/sec) is the highest

TABLE M.1
INPUT DATA FOR BIOSCREEN MODEL
BX SERVICE STATION
RANDOLPH AFB, TEXAS

	Units	Data Source
HYDROGEOLOGY		
Hydraulic Conductivity	cm/sec	Maximum value at site, ST019MW259, slug test data 11/97
Hydraulic Gradient	ft/ft	Average value at site, groundwater flow map 11/97
Porosity	-	Typical value for sand and gravel (Spitz and Moreno, 1996)
DISPERSION		
Estimated Plume Length	ft	Measured from benzene plume 11/97
ADSORPTION		
Soil Bulk Density	kg/L	Fuels Protocol (Wiedemeier *et al.*, 1995)
Partition Coefficient	L/kg	Fuels Protocol (Wiedemeier *et al.*, 1995)
Fraction Organic Carbon	-	TOC data 11/97
BIODEGRADATION		
Solute Half-Life	yr	Bioscreen Manual (Newell *et al.*, 1996)
Delta Oxygen	mg/L	Geochemical data 11/97
Delta Nitrate	mg/L	Geochemical data 11/97
Observed Ferrous Iron	mg/L	Geochemical data 11/97
Delta Sulfate	mg/L	Geochemical data 11/97
Observed Methane	mg/L	Geochemical data 11/97
GENERAL PARAMETERS		
Modeled Area Length	ft	Measured from site map
Modeled Area Width	ft	Measured from site map
Simulation Time	yr	Depends on output required (calibration vs. prediction)
SOURCE DATA		
Source Thickness in Saturated Zone	ft	Based on NAPL, soil contamination, and/or smear zone
Source Zone Width	ft	Based on dissolved contamination isocontours (1 µg/L)
Source Zone Concentration	mg/L	Inferred concentration upgradient of source area well ST019MW077
Soluble Mass in Source NAPL, Soil	kg	Based on contaminant concentrations detected in soil in Nov. 1990

value calculated from slug test data collected downgradient from the source area in November 1997. The hydraulic gradient value used in the model (0.0045 ft/ft) is derived from the groundwater elevation data collected in November 1997. The value of advective groundwater velocity calculated by BIOSCREEN® is 145 ft/yr (see Attachment M.1).

M.4.2 Dispersivity

Dispersion refers to the process whereby a plume will spread out in a longitudinal direction (along the direction of groundwater flow), transversely (perpendicular to groundwater flow), and vertically downward due to mechanical mixing and chemical diffusion in the aquifer. The longitudinal, transverse, and vertical dispersivities used in the model are calculated by BIOSCREEN® from the estimated maximum benzene plume length of 450 feet (see Attachment M.1).

M.4.3 Retardation

Retardation of benzene relative to the advective velocity of the groundwater occurs when benzene molecules are sorbed to organic carbon, silt, or clay particles in the aquifer matrix. Increasing the retardation coefficient decreases the contaminant migration velocity relative to the advective groundwater velocity, causing the contaminant to be biodegraded to a greater degree along a given travel path. Field data collected in November 1997 indicate minimum, maximum, and average total organic carbon (TOC) concentrations of 1500 mg/kg, 4500 mg/kg, and 2900 mg/kg, respectively. Using these field values, an estimated soil bulk density of 1.7 kg/L, and a partition coefficient for benzene of 79 L/kg (Wiedemeier *et al*, 1995), a minimum, maximum, and average retardation coefficient for benzene of 3.4, 1.8, and 2.6 were calculated. The minimum value of 1.8 was used in the model (see Attachment M.1) to provide a maximum contaminant migration velocity.

M.4.4 First-Order Decay Coefficient

BIOSCREEN® uses the first-order decay coefficient to simulate biodegradation of dissolved contaminants after they have migrated downgradient from the source area. The first-order decay coefficient equals the half-life of the contaminant divided by 0.693. The half-life of benzene published in literature typically ranges from 0.02 to 2 years (Newell et al, 1996). The method of Buschek and Alcantar (1995) was used to calculate a first-order decay rate from site-specific data. Using data from both November 1990 and November 1997, decay rates of 0.003 day^{-1} (1.1 $year^{-1}$) and 0.004 day^{-1} (1.5 $year^{-1}$) were calculated for benzene at the site. The average half-life calculated for this range of decay rates is 0.5 year, which is the value entered into the model (see Attachment M.1).

M.4.5 Instantaneous Reaction Data

BIOSCREEN® uses field data for certain electron acceptors and metabolic byproducts to calculate a biodegradation rate for the instantaneous reaction model. The input data include the change in dissolved oxygen, nitrate, and sulfate concentrations between the source area of the plume and an upgradient, background area and the observed ferrous iron and methane concentrations in the source area of the plume.

Geochemical data collected in November 1997 were used as the input for the instantaneous model (Attachment M.1).

M.4.6 Source Area Dimensions and Concentrations

BIOSCREEN® assumes a source represented by a vertical plane perpendicular to groundwater flow. The cross-sectional area of the vertical plane was estimated from the benzene data collected in November 1990 (Weston, 1995). The maximum benzene concentration in the UST source area was conservatively estimated to be 15,000 µg/L on the basis of the benzene concentration detected at well ST019MW077 (10,000 µg/L) in November 1990. The thickness of the contaminated soil interval was estimated to be 5 feet based on historical fluctuations of the water table (Attachment M.1). An additional source was added to represent the rupture of the AVGAS line during the summer of 1996. This spill was modeled as a separate plume (Attachment M.2) with a source width of 50 feet and a dissolved benzene concentration of 5,000 µg/L.

M.4.7 Source Half-Life

BIOSCREEN® incorporates an approximation for a declining source concentration over time. The declining source term assumes that the mass of contaminant in the source area dissolves slowly as fresh groundwater passes through, and that the change in source zone concentration can be approximated as a first-order decay process. The model will compute an estimated source half-life given the estimated mass of contaminant present in the source area. The November 1990 data are the earliest data available for the UST source area concentrations, so the source area mass was estimated from these data. The AVGAS source area mass was calculated from an estimated fuel spill of approximately 500 gallons.

M.5 MODEL CALIBRATION

The analytical model was calibrated by altering input parameters in a trial-and-error fashion until the simulated plume calculated by the first-order decay model and the instantaneous reaction model approximated observed field data. The parameters varied during calibration were the source area dimensions and concentration and the source mass. The parameters were varied within a conservative and realistic range of values until the seven-year run results of the first-order decay model and the instantaneous reaction model closely matched the 1997 dissolved benzene data at well ST019MW077 (see Attachment M.3) and source area of the AVGAS pipeline leak (Attachment M.4). The final input data for the plume emanating from the former UST area, as shown in Attachment M.1, include a 150-foot wide source area of 30,000 µg/L and a benzene source mass of 4,000 kg (or a release of approximately 1,600 gallons of fuel). The final input data for the plume emanating from the AVGAS line leak, as shown in Attachment M.2, include a 50-foot wide source area of 3,500 µg/L and a benzene source mass of 1,250 kg (or a release of approximately 500 gallons of fuel).

M.6 Model Results

The calibrated models for each source area were run for an additional 13 years beyond 1997 to predict the maximum plume extent and concentrations over time. Results of the model run for the former underground storage tank system source area

are shown on Attachments M.5, M.6, and M.7 and summarized in Table M.2. Results of the model run for the AVGAS pipeline source area are shown on Attachments M.8, M.9, and M.10 and summarized in Table M.3.

Table M.2
Predicted Results at 400 Feet Downgradient from Source Area - Plume 1
BX Service Station
Randolph AFB, Texas

Model Year	First-order Decay Model	Instantaneous Reaction Model
1997	108 µg/L	174 µg/L
2000	106 µg/L	4,356 µg/L
2005	103 µg/L	0 µg/L
2010	100 µg/L	0 µg/L
Maximum Migration Distance	700 ft	500 ft-600 ft

The First-order Decay Model predicts that the plume has been receding since 1997 and will not extend beyond 700 feet downgradient from the source area. The Instantaneous Reaction Model predicts that the dissolved benzene plume will reach it's maximum downgradient extent (500 feet downgradient from the source area) between 1997 and the year 2000, and then concentrations will quickly decrease to below the TNRCC groundwater quality standards.

Table M.3
Predicted Results at 300 Feet Downgradient from Source Area - Plume 2
BX Service Station
Randolph AFB, Texas

Model Year	First-order Decay Model	Instantaneous Reaction Model
1997	1 µg/L	0 µg/L
2000	30 µg/L	0 µg/L
2005	30 µg/L	0 µg/L
2010	30 µg/L	0 µg/L
Maximum Migration Distance	500 ft	< 50 ft

The First-order Decay Model predicts that the plume will be stable by the year 2005. The Instantaneous Reaction Model predicts that the maximum downgradient extent of the dissolved benzene plume will less than 50 feet from the source area, with concentrations quickly falling below TNRCC groundwater quality standards.

M.7 CONCLUSIONS

The following conclusions are drawn from this modeling exercise:

1. The results presented for Plume 1 are considered conservative due to the fact that benzene was not detected in any perimeter wells above the project reporting limit during the November 1997 sampling event. Modeling results indicate that benzene should have been detected at approximately 100 to 200 μg/L.

2. The maximum predicted downgradient migration for Plume 1 was 720 feet from the source area (First-order Decay Model). The Instantaneous Reaction Model predicted a maximum migration of 500 feet. However, due to the conservative nature of the results, migration of benzene to these distances is not expected. One objective of the proposed future groundwater monitoring events is to confirm this observation.

3. The maximum predicted downgradient migration for Plume 2 was 500 feet from the source area (First-order Decay Model). The Instantaneous Reaction Model predicted less than 50 feet of migration.

4. Although not entirely representative of what is occurring at the site, these results indicate that the potential for dissolved contaminants to migrate to off-site receptor exposure points is low, and that the groundwater concentrations will continually decrease via natural attenuation.

M.8 REFERENCES

Domenico, P.A., 1987, An analytical model for multidimensional transport of a decaying contaminant species: Journal of Hydrology, v. 91, p. 49-58.

Newell, C.J., McLeod, R. K., and Gonzales, J.R., 1996, Bioscreen: Natural Attenuation Decision Support System User's Manual, Version 1.3 and 1.4: National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Spitz, K., and Moreno, J., 1996, A Practical Guide to Groundwater and Solute Transport Modeling: John Wiley & Sons, Inc., New York, 461 p.

Weston, 1995 (this is a site specific report from which I collected data for input into the model; I don't have this report anymore)

Wiedemeier, T.H., Wilson, J.T., Kampbell, D.H., Miller, R.N., and Hansen, J.E., 1995, Technical Protocol For Implementing Intrinsic Remediation With Long-Term Monitoring For Natural Attenuation Of Fuel Contamination Dissolved In Groundwater: US Air Force Center for Environmental Excellence, San Antonio, Texas.

Attachment M.1
Bioscreen Input - Plume 1
BX Service Station
Randolph AFB, Texas

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Run Name: Randolph AFB / BX Service Station

Data Input Instructions:
1. Enter value directly.. or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below)

Variable* → Data used directly in model
20 → Value calculated by model (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	145.3	(ft/yr)
or		*or*	
Hydraulic Conductivity	K	7.8E-03	(cm/sec)
Hydraulic Gradient	i	0.0045	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	17.0	(ft)
Transverse Dispersivity*	alpha y	1.7	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		*or*	
Estimated Plume Length	Lp	450	(ft)

3. ADSORPTION

Retardation Factor*	R	1.8	(-)
or		*or*	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	79	(L/kg)
FractionOrganicCarbon	foc	1.5E-3	(-)

4. BIODEGRADATION

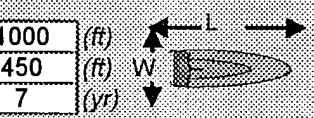
1st Order Decay Coeff*	lambda	1.4E+0	(per yr)
or		*or*	
Solute Half-Life	t-half	0.50	(year)

or Instantaneous Reaction Model

Delta Oxygen*	DO	1.84	(mg/L)
Delta Nitrate*	NO3	3.2	(mg/L)
Observed Ferrous Iron*	Fe2+	5.8	(mg/L)
Delta Sulfate*	SO4	76.7	(mg/L)
Observed Methane*	CH4	77	(mg/L)

5. GENERAL

Modeled Area Length*		1000	(ft)
Modeled Area Width*		450	(ft)
Simulation Time*		7	(yr)



6. SOURCE DATA

Source Thickness in Sat.Zone* 5 (ft)

Source Zones:

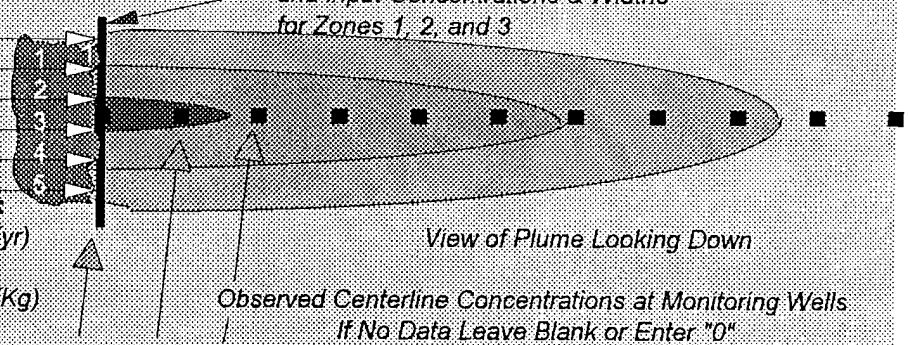
Width* (ft)	Conc. (mg/L)*
0	0
0	0
150	30
0	0
0	0

Source Halflife (see Help):

Inst. Reactor	1st Order
20	100 (yr)

Soluble Mass 4000 (Kg)
In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)		7.0	1.0	.1	.001						
Dist. from Source (ft)	0	100	200	300	400	500	600	700	800	900	1000

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE — **View Output**

RUN ARRAY — **View Output**

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Attachment M.2
Bioscreen Input - Plume 2
BX Service Station
Randolph AFB, Texas

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.4*

Randolph AFB
BX Service Station
Plume 2

Data Input Instructions:
115 ▷ 1. Enter value directly... or
or
0.02 ▽ 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Variable* ▷ Data used directly in model.
20 ▷ Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	145.3	(ft/yr)
or		*or*	
Hydraulic Conductivity	K	7.8E-03	(cm/sec)
Hydraulic Gradient	i	0.0045	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	16.5	(ft)
Transverse Dispersivity*	alpha y	1.6	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		*or*	
Estimated Plume Length	Lp	420	(ft)

3. ADSORPTION

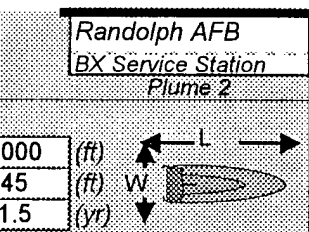
Retardation Factor*	R	1.8	(-)
or		*or*	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	79	(L/kg)
FractionOrganicCarbon	foc	1.5E-3	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	1.4E+0	(per yr)
or		*or*	
Solute Half-Life	t-half	0.50	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	1.13	(mg/L)
Delta Nitrate*	NO3	3.2	(mg/L)
Observed Ferrous Iron*	Fe2+	0	(mg/L)
Delta Sulfate*	SO4	76.7	(mg/L)
Observed Methane*	CH4	15	(mg/L)

5. GENERAL

Modeled Area Length*	1000	(ft)
Modeled Area Width*	45	(ft)
Simulation Time*	1.5	(yr)



6. SOURCE DATA

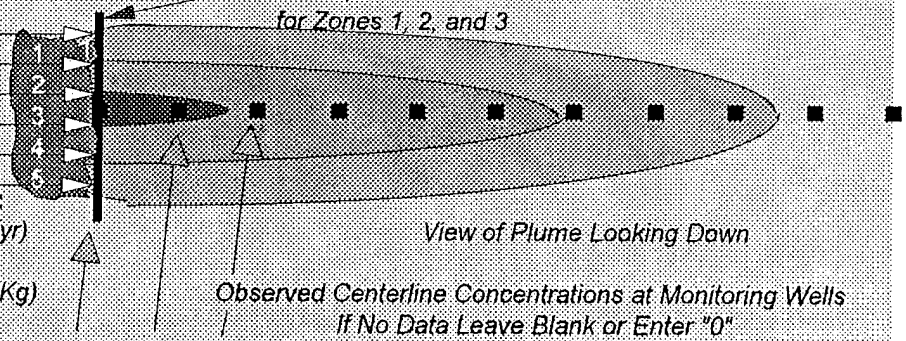
Source Thickness in Sat.Zone* 5 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
0	0
0	0
50	3.5
0	0
0	0

Source Halflife (see Help): 80 | 1000 (yr)
Inst. React. | 1st Order
Soluble Mass 1250 (Kg)
In Source NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	Dist. from Source (ft)
3.5	0
.6	100
.1	200
.001	300
	400
	500
	600
	700
	800
	900
	1000

8. CHOOSE TYPE OF OUTPUT TO SEE:

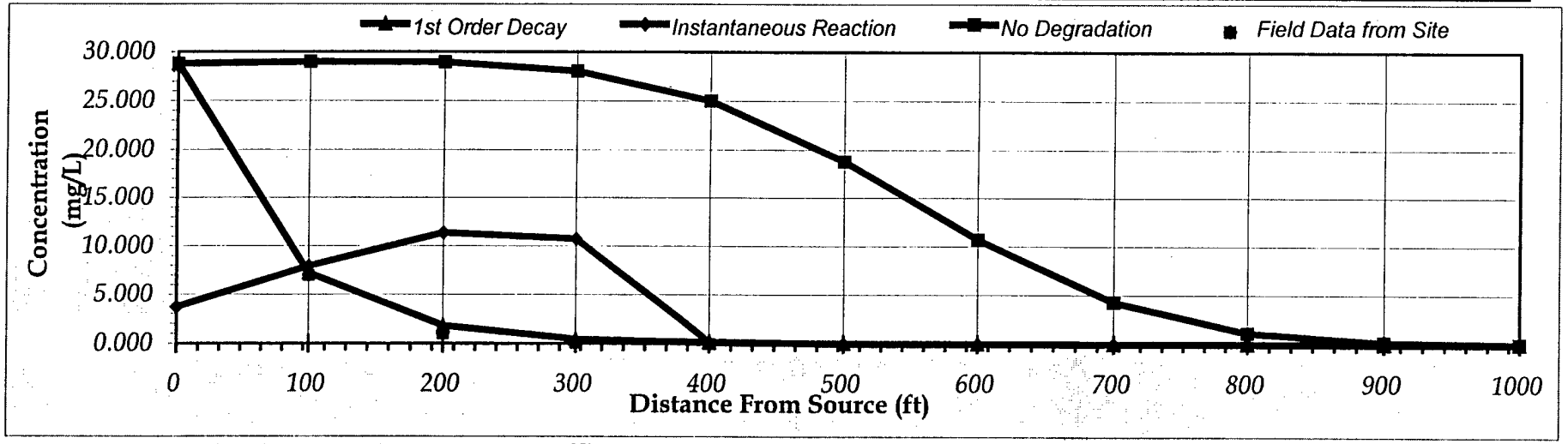
RUN CENTERLINE — View Output
RUN ARRAY — View Output

Help
Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

Attachment M.3
Bioscreen Output - Plume 1
BX Service Station
Randolph AFB, Texas

1997 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	28.810	29.005	28.981	28.050	25.007	18.783	10.698	4.241	1.110	0.185	0.019
1st Order Decay	28.810	7.208	1.796	0.443	0.108	0.026	0.006	0.001	0.000	0.000	0.000
Inst. Reaction	3.716	7.955	11.377	10.770	0.174	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site		7.000	1.000	0.100	0.001						



Calculate Animation

Time: 7 Years

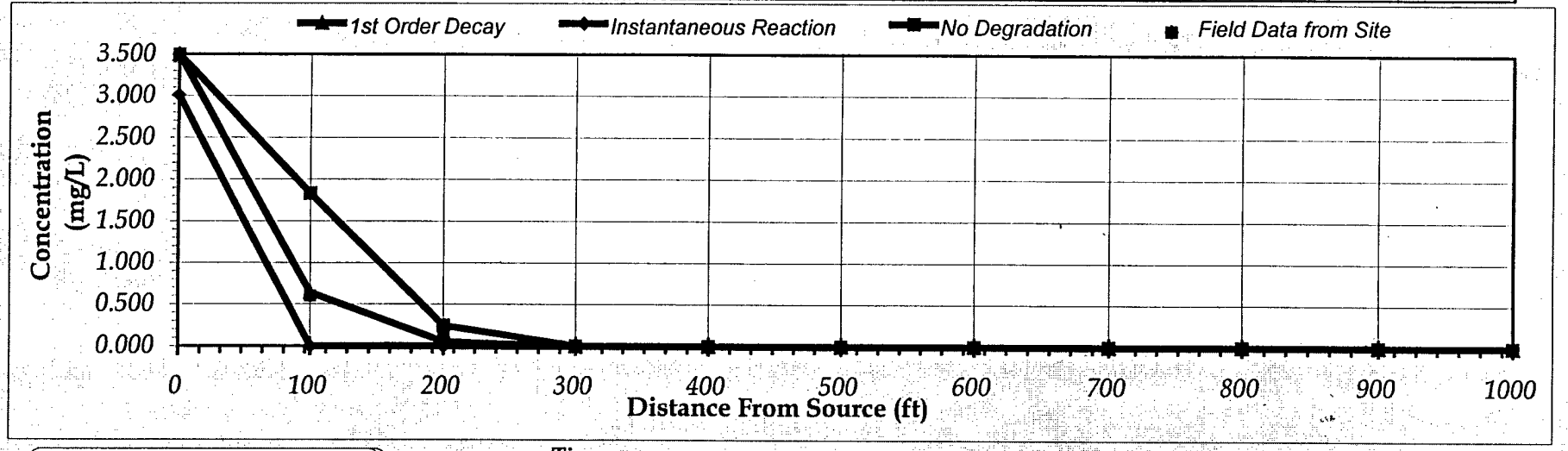
Return to Input

Recalculate This Sheet

Attachment M.4
Bioscreen Output - Plume 2
BX Service Station
Randolph AFB, Texas

1997 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	3.496	1.829	0.244	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	3.496	0.636	0.050	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	3.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	3.500	0.600	0.100	0.001							



Calculate Animation

Time: 1.5 Years

Return to Input

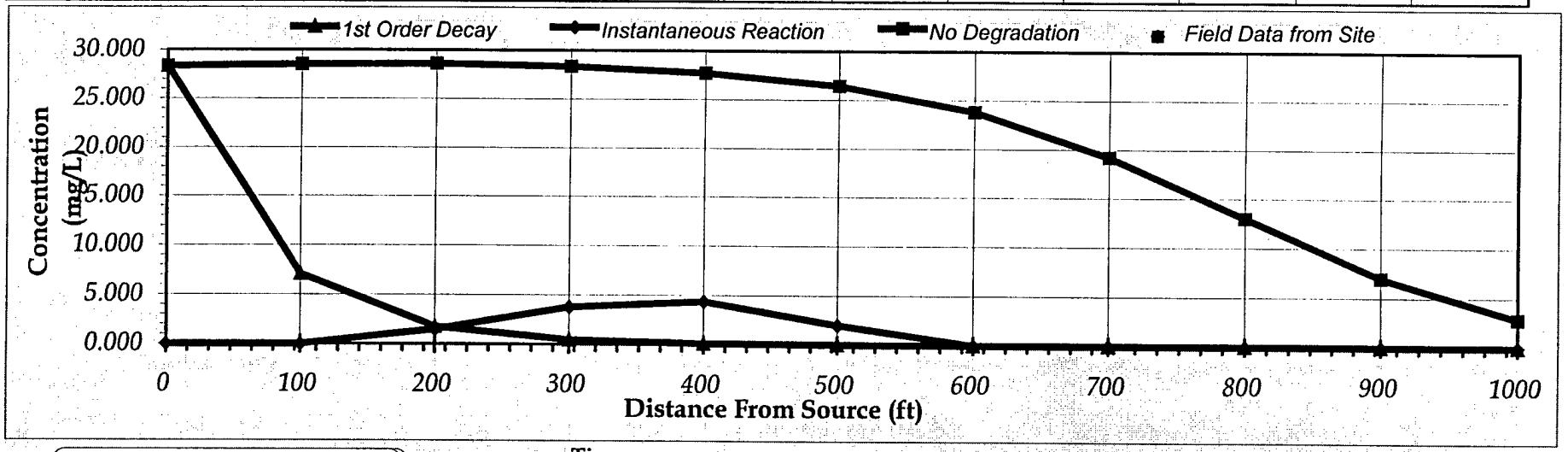
Recalculate This Sheet

Attachment M.5
Bioscreen Output - Plume 1
BX Service Station
Randolph AFB, Texas

2000 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

Distance from Source (ft)

TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	28.315	28.517	28.604	28.350	27.708	26.420	23.797	19.184	13.006	6.971	2.854
1st Order Decay	28.315	7.084	1.765	0.435	0.106	0.026	0.006	0.002	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	1.487	3.751	4.356	1.999	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 10 Years

Return to Input

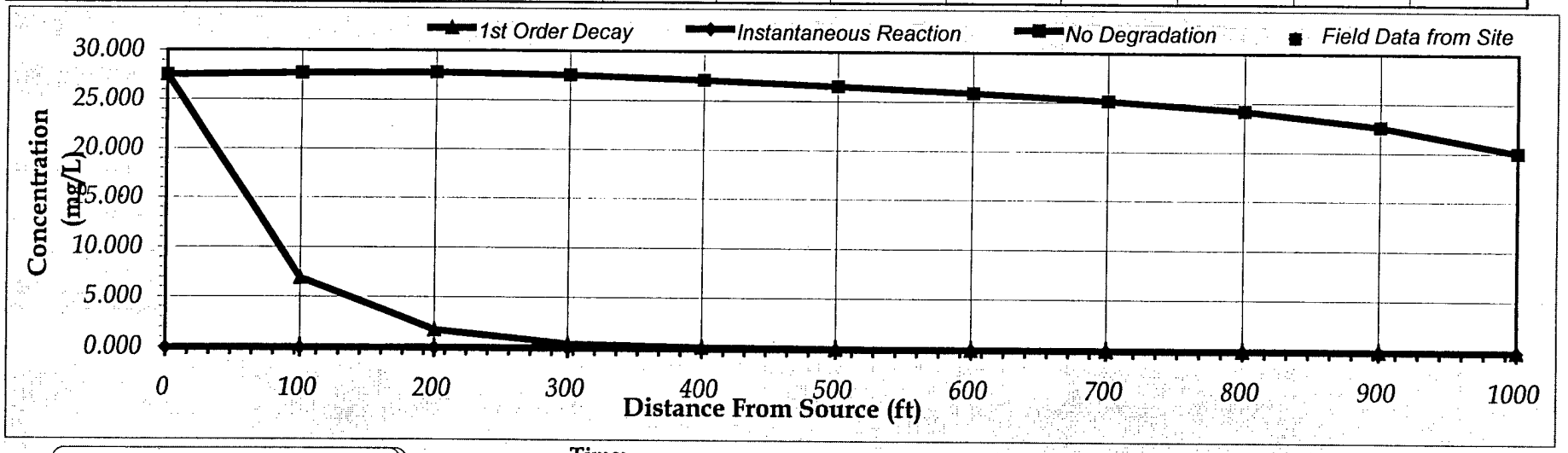
Recalculate This Sheet

Attachment M.6
Bioscreen Output - Plume 1
BX Service Station
Randolph AFB, Texas

2005 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

Distance from Source (ft)

TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	27.508	27.705	27.793	27.574	27.115	26.536	25.895	25.166	24.187	22.617	20.034
1st Order Decay	27.508	6.883	1.715	0.423	0.103	0.025	0.006	0.001	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 15 Years

Return to Input

Recalculate This Sheet

EXHIBIT N

SOIL BORING LOGS AND MONITOR WELL CONSTRUCTION DIAGRAMS

Versar

Lithology Log — Sheet 1 of 1

LOCID: STØ19MW258

Project Name: RAFB - AAFES Station	Project Number: 2820	LTCCODE	SITE ID / LPRCODE
Drilling Company: Core Terra	Driller: Mark Monroe	Ground Elevation	Total Drilled Depth
Drilling Equipment: Mobile B-61	Drilling Method: HSA	Borehole Diameter: 4¼"	Date/Time Drilling Started: 11/12/97 1235
Type of Sampling Device: 5' Core Barrel		Water Level (bgs) First: 27.0' Final	Date/Time Total Depth Reached: 11/12/97 1640
Sample Hammer Type: Driving Wt. Drop		Hydrogeologist: K. Banerjee / T. Smith	Checked by/Date

Location Description (include sketch in field logbook): AAFES Station Tank Pad (NW)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				Asphalt 4"; Sandfill 8"; Fill - pea gravel to ¼" diameter							
5											
				Silty clay; brownish-yellow (10YR 6/6); low plasticity; damp; trace gravel to ½"; sub-rounded.	ML-CL			5	5	90	Slight HC Odor; PID = 267 ppm
10	6"										
				Increase in sand; decrease in gravel content				–	15	85	No HC odor; PID = 56 ppm
15	24"										
				Grades w/ lighter colored laminations white (10YR 8/1); increase in development of caliche.							Slight HC odor; PID = 139 ppm
20	18"										
				Siltstone; 0.25" weathered laminations; V. dense; dry; brownish yellow (10YR 6/6)			▽				Strong HC odor; PID = 601 ppm Driller reports harder drilling @ 26-27' Collected sample
25	36"										
				Gravelly clay; well-graded; sub-angular to sub-rounded gravel to 1"; dense; wet; light gray (10YR 7/2) w/ oxidized laminae	CL			40	10	50	Slight HC odor; PID = 77
30	48"										
				BOH @ 34.0'							Note: Driller will ream down hole w/ 12" OD Auger to install Air Injection Well / Recovery Well (Dual) - 4" casing

Figure 2.2

Versar

Lithology Log

Sheet 1 of 1

LOCID: ST0195B259

Project Name: RAFB - AAFES Station	Project Number: 2920	LTCCODE	SITE ID / LPRCODE
Drilling Company: Core Terra	Driller: John Morano	Ground Elevation	Total Drilled Depth: 41'
Drilling Equipment: Mobile B-61	Drilling Method: HSA	Borehole Diameter: 4.25"	Date/Time Drilling Started: 11/19/97 1400
			Date/Time Total Depth Reached: 11/20/97 41'
Type of Sampling Device: 2" Sampler (SS)		Water Level (bgs) First: 36.5'	Final: 36'
Sample Hammer Type: Driving Wt. Drop		Hydrogeologist: John Tuggy / Tom Smith	Checked by/Date: T Smith 11/20/97

Location Description (include sketch in field logbook): AAFES Station Tank Pad (NE)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
				4" Asphaltic Concrete	AC						
				Silty clay, moderately plastic; w/fine sand, damp							
5			3 3 3								mod. chemical odor; PID=156 ppmv @ 5.0' BGS.
				Silt w/ sand; very low plasticity, dense, dry, brownish yellow							
10			7 12 15								slight hydrocarbon odor PID = 144 ppmv. @ 10.0'
				– less dense –							
15			10 15 17	– Lighter color, pale brown,							No disc. odor; PID = 43 ppmv @ 15.0'
				– becoming dense @ 21-22							
20			8 17 24								No disc. odor; PID = 59 ppmv @ 20.0'
				Sand w/ silt, light brown, damp, some clay							
25			50/4								Slight H. carb odor PID = 133 ppmv @ 25.0'
30			22 50	Siltstone, dense, dry, pale brown							slight H. carb odor PID = 92 ppmv @ 30.0'
				wet @ 36', increased sand							
35				very dense at 38', 5 cps							
40			50/4								
				BOH - 41'							

Figure 2.2

Versar

ST0195B260

Lithology Log — Sheet 1 of

Project Name: RAFB-AAFES Station	Project Number: 2820	LTCCODE	LOCID: SUMP#2; SITE ID; LPRCODE
Drilling Company: Core Terra	Driller: Mark Monroe	Ground Elevation	Total Drilled Depth: 34.0'
Drilling Equipment: Mobile B-61	Drilling Method: HSA	Borehole Diameter: 4¼"	Date/Time Drilling Started: 11/14/07 1245
			Date/Time Total Depth Reached: 11/14/07 1620
Type of Sampling Device: 2' Scraplex/5' Core Barrel		Water Level (bgs): First 28.85'	Final
Sample Hammer — Type: Driving Wt. Drop		Hydrogeologist: K. Banerjee/T. Smith	Checked by/Date
Location Description (include sketch in field logbook): AAFES Station Tank Pad (SW)			

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
		24"		Asphalt 2"; Topsoil							
		24"		Silty clay; moderately plastic; fine sand; damp; gravel to 0.2"; black (2.5/N); organics	OH			10	10	80	No odor; PID = 10.2 ppm PID = 15 ppm Slight odor; PID = 115 ppm
5		36"		Silt w/ sand; v. low plasticity; V. dense; dry; fine sand; brownish-yellow (10YR 6/6)	ML			–	20	80	Slight odor; PID = 54 ppm Slight odor; PID = 122 ppm
10		48"		Grades less dense; damp;							No odor; PID = 36 ppm
		12"		Increase in sand content				–	30	70	No odor; PID = 21 ppm
15											
20		60"		Grades lighter colored (10YR 8/1) @ 22.0'							Drillers reports harder drilling @ 23.0'
25		60"		Grades to Silty Sand	ML-SM			–	50	50	No odor; PID = 36.0 ppm
				Increase in clay content; wet			▽				
30		60"		Siltstone; V. dense; dry; laminated black partings w/ slickenside alongs fractures; V. pale brown (10YR 8/2)							No odor; PID = 2.0 ppm
35				BOH @ 34.0'							Driller completed boring

Figure 2.2

Versar

Lithology Log — Sheet ___ of ___

LOCID: ST0195B261

Project Name	Project Number	LTCCODE	SITE ID	LPRCODE
RAFB - AAFES Svc. Stn.	2820-			

Drilling Company	Driller	Ground Elevation	Total Drilled Depth
Core Terra	S. Moreno		

Drilling Equipment	Drilling Method	Borehole Diameter	Date/Time Drilling Started	Date/Time Total Depth Reached
Mobile B-61	HSA	8"	11/18/97	

Type of Sampling Device: 2" ID Split Spoon

Water Level (bgs): First ___ Final ___

Sample Hammer — Type ___ Driving Wt. ___ Drop ___

Hydrogeologist: J. Trigg

Checked by/Date: ___

Location Description (include sketch in field logbook): AAFES Station (W) of Pump Canopy

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
5			4 8 15	Black silty clay w/ roots + other organics, (2.5/N) fine to med sand. Damp. Plastic. v. low est K.	OH			5	20	75	Organic Odor, PID = 18.0 ppmv @ 5.0'
10			12 16 21	SILT w/ sand; damp, brownish-yellow (10YR, 6/6), fine to med. sand. v. stiff, v. low est K	ML			–	30	70	ϕ Odor, PID = 26.0 ppmv @ 10.0'
15			10 15 25								ϕ odor, PID = 49.0 ppmv @ 15.0'
20			12 43 23	Silty SAND: moist, brownish yellow (10YR, 6/6), f. to coarse sand, dense, modest. K.	SM			–	75	25	ϕ odor, 93 ppmv @ 20.0'
25			20 40 50/4	silt w/ Sand; moist							ϕ odor, 64 ppmv @ 25.0'
30			50/2				▽				wet @ ~30.0'
35			50 5/4	Gravelly Clay; poorly graded angular to subrounded gravel to ~.75", saturated brownish yellow (10YR 4/6). saturated high est K	CL			30	10	60	ϕ odor, PID = 11 ppmv @ 30.0'
											ϕ odor, PID = 7.0 ppmv @ 35.0'

Figure 2.2

Geologic Log

Versar

Sheet 1 of 1

LOCID: ST Ø19MW203

Lithology Log

Project Name: RAFB - AAFES Station	Project Number: 2820	LTCCODE	SITE ID / LPRCODE
Drilling Company: Core-Terra	Driller: Mark Monroe	Ground Elevation	Total Drilled Depth: 34.0'
Drilling Equipment: Mobile B-61	Drilling Method: HSA	Borehole Diameter: 4 1/4"	Date/Time Drilling Started: 11/11/97 1430
Type of Sampling Device: 5' Core Barrel		Water Level (bgs) First: None	Date/Time Total Depth Reached: 11/12/97 0825
Sample Hammer Type:	Driving Wt. / Drop	Hydrogeologist: K. Banerjee / T. Smith	Checked by/Date

Location Description (include sketch in field logbook): Harmon Drive Median East of Credit Union Bldg.

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
		24"		Top soil w/ some clay; black to dark gray; root material; dry							No odor; PID = 0.0 ppm
5		30"		Silty gravel w/ sand; well graded gravel to 0.75" sub-rounded; dense; damp; yellowish brown (10 YR 4/4)	GM			50	15	35	No odor; PID = 0.0 ppm
10											No recovery
				Grades to poorly graded gravel							No odor; PID = 1.4 ppm
15		24"									
											No odor; PID = 1.5 ppm
20		12"									
25		98"		Siltstone w/ sand; v. pale brown (10 YR 8/2); very dense; laminated black partings w/ slickensides and iron staining; v. dry.	ML-CL			-	20	80	No odor; PID = 0.0 ppm Drilling suspended until next day to check for water. No odor; PID = 0.0 ppm No H_2O in hole.
30		60"									
35				BOH @ 34.0'							Boring abandoned due to lack of water production.

Figure 2.2
Geologic Log

Versar

Lithology Log — Sheet 1 of ___

LOCID: STP95B262

Project Name: RAFB-AAFES Station	Project Number: 2820	LTCCODE	SITE ID / LPRCODE
Drilling Company: Core Tessa	Driller: Juri Mneno	Ground Elevation	Total Drilled Depth: 34'
Drilling Equipment: Mobile B-61	Drilling Method: HSA	Borehole Diameter: 4 1/4"	Date/Time Drilling Started: 11/17/97 0910
			Date/Time Total Depth Reached: 11/18/97 1105
Type of Sampling Device: 2' Samples / 5' Core Barrel		Water Level (bgs): First 32'	Final
Sample Hammer — Type / Driving Wt. / Drop		Hydrogeologist: K. Banerjee / J. Trigg	Checked by/Date

Location Description (include sketch in field logbook): AAFES Station - NW of Canopy in Grass Area

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0		20"		Top soil; black silty clay w/root material; organics (2.5/N); fine sand	OH			5	15	80	No odor; PID = 6.2 ppm
		24"									No odor; PID = 2.8 ppm
5											No odor; PID = 10.7 ppm
		90"		Silt w/ sand; damp; v. low plasticity; medium dense; fine sand; brownish-yellow (10YR 6/6)	ML			-	20	80	No odor; PID = 7.7 ppm
10				Grades v. dense							No odor; PID = 21.7 ppm
15				Increase in sand content	ML-SM			-	40	60	v. hard drilling
20											
25			17 33 43	Clayey silt							No odor; PID = 22.3 ppm
30		6 6 6	5 9/4								
				Driller contact			▽				
			10 15 22	Gravelly CLAY; poorly graded; subangular to angular grand to ~.75"; saturated; brownish yellow (10YR 6/6), highest K	CL			35	10	55	No Odor, PID = 18.0 ppm
35				Sandy Fat Clay, wet, yellowish brown (10YR 6/6) mottled (5G 7/2) pale green; f. to med sand lowest K				5	35	60	No Odor, PID = 7.0 ppm
				BOH @ 36.0' BGS							

Figure 2.2

Versar

Lithology Log — Sheet 1 of 1

LOCID: STØ19MW264

Project Name: RAFB-AAFES Station	Project Number: 2820	LTCCODE	SITE ID / LPRCODE
Drilling Company: Core Tessa	Driller: Mark Monroe	Ground Elevation	Total Drilled Depth: 29.0'
Drilling Equipment: Mobile B-61	Drilling Method: HSA	Borehole Diameter: 4¼"	Date/Time Drilling Started: 11/11/97 0940
Type of Sampling Device: 5' Core Barrel / 2' Split Spoon	Water Level (bgs): First 25.0'	Final	Date/Time Total Depth Reached: 11/11/97 1130
Sample Hammer — Type: Hydraulic; Driving Wt.; Drop	Hydrogeologist: K. Banerjee / T. Smith		Checked by/Date
Location Description (include sketch in field logbook): South side of Credit Union Bldg			

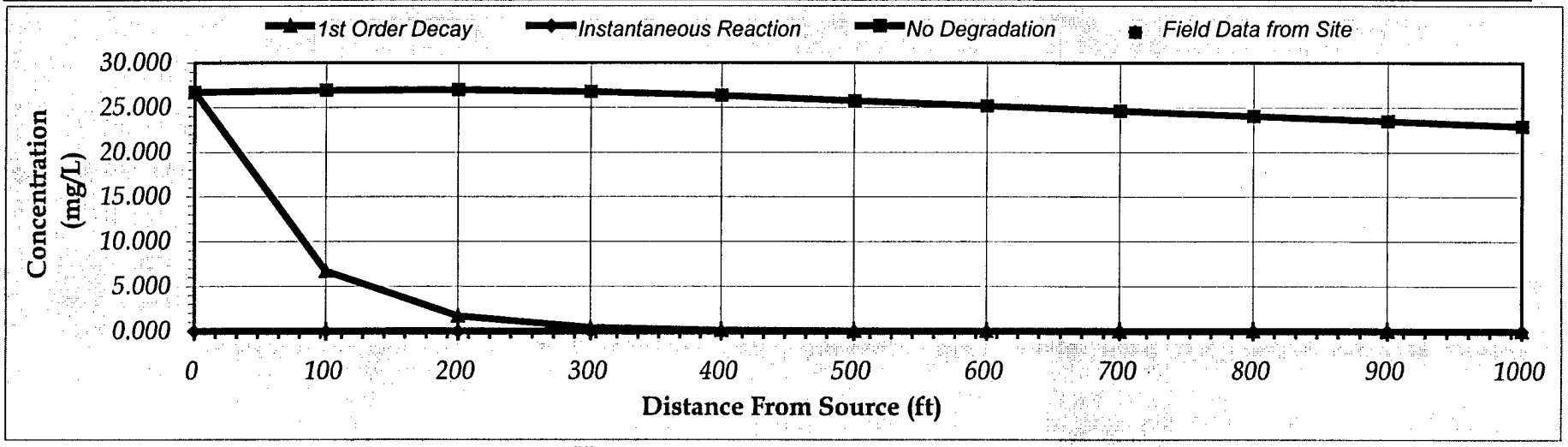
Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, mineralogy, bedding, plasticity, density, consistency, etc., as applicable)	USCS Symbol	Lithology	Water Content	Estimate % of Gr	Sa	Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
		12"		Asphalt 2" Fill; construction debris w/ sand clay nodules							
5		30"		Silty clay; brownish yellow (10YR 6/6); moderately plastic, moist 80% clay, 20% silt; lowest K.	CL			–	5	95	No odor; PID = 0.0 ppm
10		24"		Grades increase in gravel content and silt content (30%) Gravel to 0.5"				20	5	75	No odor; PID = 0.0 ppm
15		24"		Silty Gravel; widely graded to 1.0"; sub-rounded; fine sand; dense; chert nodules	GM			40	10	50	No odor, PID = 0.0 ppm
20		24"		Grades increase in silt				20	10	70	No odor; PID = 2.1 ppm
25		3"	50/3								No odor; PID = 0.0 ppm
30				BOH @ 29.0'							

Figure 2.2
Geologic Log

Attachment M.7
Bioscreen Output - Plume 1
BX Service Station
Randolph AFB, Texas

2010 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	26.724	26.916	27.001	26.789	26.344	25.786	25.192	24.601	24.031	23.476	22.900
1st Order Decay	26.724	6.686	1.666	0.411	0.100	0.024	0.006	0.001	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 20 Years

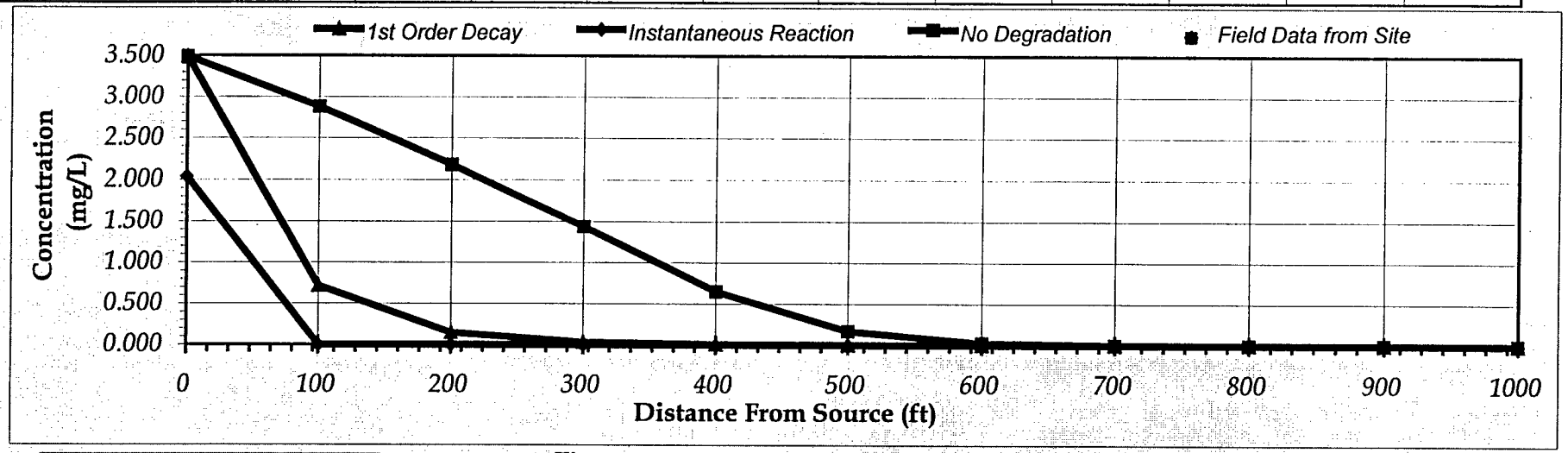
Return to Input

Recalculate This Sheet

Attachment M.8
Bioscreen Output - Plume 2
BX Service Station
Randolph AFB, Texas

2000 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	3.489	2.880	2.180	1.435	0.648	0.167	0.022	0.001	0.000	0.000	0.000
1st Order Decay	3.489	0.716	0.142	0.030	0.006	0.001	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	2.043	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 4.5 Years

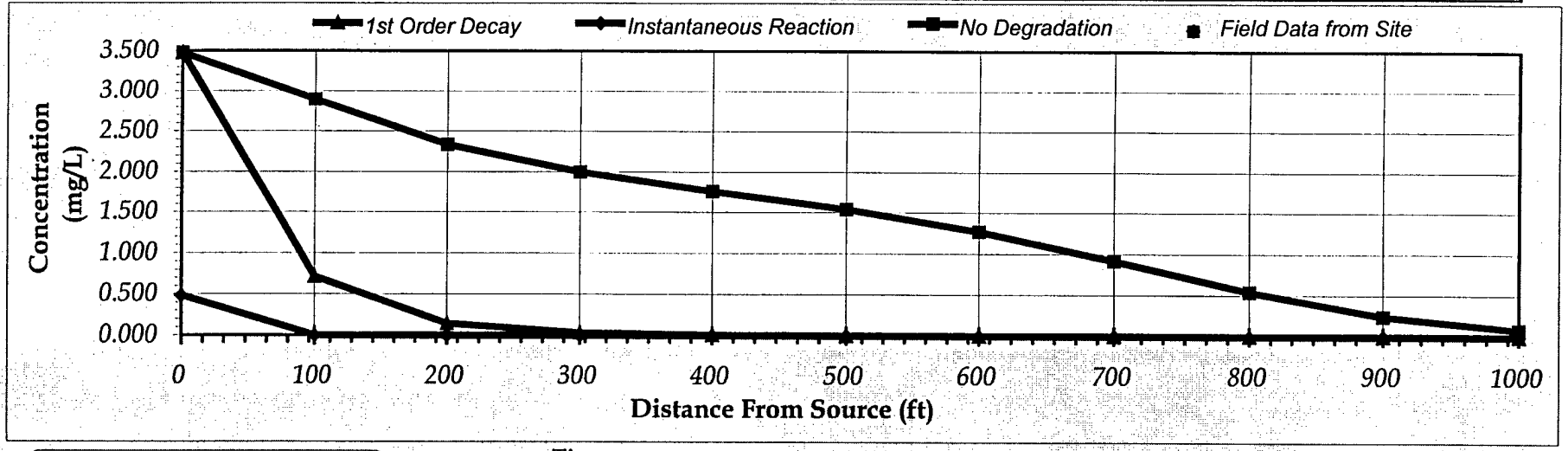
Return to Input

Recalculate This Sheet

Attachment M.9
Bioscreen Output - Plume 2
BX Service Station
Randolph AFB, Texas

2005 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	3.476	2.894	2.333	1.996	1.757	1.537	1.266	0.914	0.537	0.243	0.081
1st Order Decay	3.476	0.713	0.142	0.030	0.007	0.001	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.485	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 9.5 Years

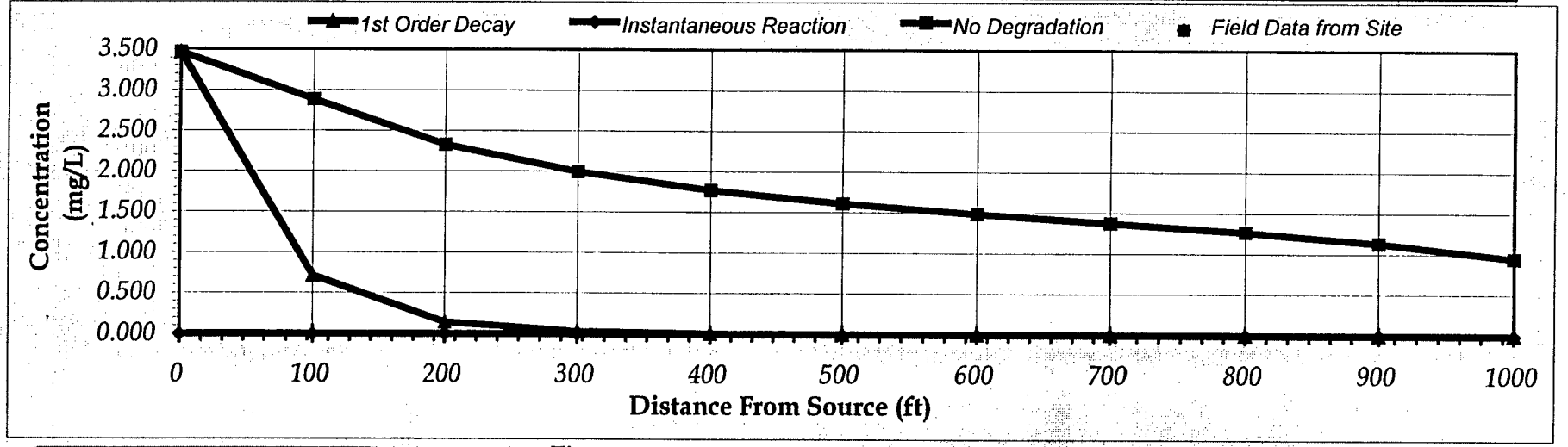
Return to Input

Recalculate This Sheet

Attachment M.10
Bioscreen Output - Plume 2
BX Service Station
Randolph AFB, Texas

2010 **DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)**

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	3.464	2.883	2.325	1.992	1.770	1.608	1.481	1.373	1.264	1.128	0.945
1st Order Decay	3.464	0.711	0.141	0.030	0.007	0.001	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time: 14.5 Years

Return to Input

Recalculate This Sheet

Walton, Norman

From: Hansen, Jerry E, Mr, HQAFCEE [Jerry.Hansen@HQAFCEE.brooks.af.mil]
Sent: Tuesday, August 08, 2000 10:16 AM
To: 'nwalton@dtic.mil'
Subject: Distribution statement for AFCEE/ERT reports

Norman, This is a followup to our phone call. The eight boxes of reports you received from us are all for unlimited distribution. If you have any questions, you can contact me at DSN 240-4353.